EXHIBIT D

IN THE COURT OF COMMON PLEAS
PHILADELPHIA COUNTY

Bruce and Janice Rhyne, his wife,	)	
	)	
	)	
Plaintiffs,	)	
	)	
vs.	)	No. 0228
	)	
U.S. Steel Corp., et al.,	)	
	)	
Defendants.		

EXPERT REPORT OF
ROBERT F. HERRICK, Sc.D., CIH, FAIHA

BACKGROUND

Bruce C. Rhyne graduated high school in 1975.[1] He started out with Duke Power in 1976 as a railroad technician for about 3 months and then went into pipefitting in a fabrication (fab) shop; later in his career he became a mechanic.[2] From 1976 until he left employment due to his Leukemia, he had been employed with Duke Power.[3] He was diagnosed with Leukemia in May 2015.[4]

HIGH SCHOOL AUTO MECHANIC CLASS

During Junior and Senior year of high school, Mr. Rhyne attended an auto mechanics class where they worked on vehicles as well as small motors.[5] He reported that this class was more hands on and that he repaired parts; the class was every day for 2-3 hours.[6] Classroom time was 10-20% of the time with the remaining for hands on work and parts washing.[7] There were about eight students in the shop class.[8]

Mr. Rhyne reported using Liquid Wrench to loosen bolts and Safety-Kleen parts washer utilizing a brush to clean parts including carburetors, bolting on valve covers and bolting on transmissions.[9] He estimated spending one hour to one hour and one-half using Liquid Wrench at the mechanic shop in school at least 4 days a week.[10] Mr. Rhyne also used Kutzit at the mechanic shop in his school.[11] He recalled a pair of rubber gloves he used at the parts washer.[12]

SETZER BUICK AND PONTIAC

While in high school, Mr. Rhyne was also loaned out to Setzer Buick and Pontiac in Lincolnton, North Carolina, to learn more about auto mechanics; he worked 4 hours, once a week.[13] During this time at Setzer, he mainly cleaned parts and gaskets for the mechanic at the shop.[14] He reported, "we would do their grunt work, their cleaning, and let them spend most of the time making the repairs.[15] He would use Liquid Wrench to remove parts including break valve covers and oil pans; he would also use the Safety-Kleen parts washer to clean bolting for transmissions,

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[1] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 20.
[2] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 16-17.
[3] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 18.
[4] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 142.
[5] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 303, 562.
[6] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 304-305, 563-564, 660-661.
[7] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 572.
[8] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 575.
[9] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 19, 26, 303, 569.
[10] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 305-306.
[11] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 317.
[12] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 26, 31.
[13] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 19, 29, 305, 584-585.
[14] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 19-20, 29-30.
[15] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 304.

nuts, valve covers, and other parts.[16] He recalled a pair of rubber gloves he used at the parts washer.[17] Out of the 4 hours at Setzer's, he estimated spending 2-3 hours or 60% of the day cleaning parts at the parts washer with 1 hour for breaking things apart; he would be using the liquid wrench during this 1 hour of breaking things apart.[18] He would spend the rest of his time watching the mechanics as they put the parts back together.[19] Mr. Rhyne recalled his fingers cracking during the time he worked at Setzer's.[20]

Also, Mr. Rhyne recalled using Kutzit at Setzer's to scrape gaskets off including valve cover gaskets; he recalled using gloves while working with Kutzit at Setzer's but no respiratory protection.[21] While at Setzer's he estimated spending an hour using Kutzit to remove gaskets on the days he removed gaskets.[22]

HOME AUTO-MECHANIC WORK

Mr. Rhyne also worked on his own cars at home, which involved pulling transmission, replacing transmissions, working on motor and valve covers among other tasks; he recalled using Liquid Wrench for his home auto work.[23] He also helped his dad with auto work at home and used Liquid Wrench.[24] He recalled that the last time he worked on his father's cars would have been in the 1978 timeframe.[25] He estimated spending 6-7 hours working on his dad's car in a month timeframe before he started working at Duke.[26]

He wouldn't help his father on his vehicle every day but reported working on it with him sometimes when he got off work and sometimes on the weekend for 3-4 hours.[27] When he would work under the hood of his car outdoors, he would lean over and squirt without gloves and recalled getting it on his hands. When he would work on his car over the ditch, Liquid Wrench would back splash on him—his face and chest as he would squirt it on his transmission to get bolts loosened up.[28] For his home auto use, he recalled using Liquid Wrench on bolting to take valve covers off; he would also use it to loosen bolting while working underneath his car over the ditch at home.[29]

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[16] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 23, 304, 586-587.
[17] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 26, 31.
[18] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 31, 306, 588.
[19] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 31.
[20] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 32.
[21] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 30, 42, 588-589, 656, 662-663.
[22] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 661-662.
[23] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 20-21, 227.
[24] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 20-21.
[25] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 650.
[26] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 650.
[27] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 330.
[28] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 314-315.
[29] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 226.

Mr. Rhyne estimated working on his car, a '55 Chevrolet, two days a week.[30] He would mostly work on his car during the summer months.[31] He recalled changing his own oil and working on his transmission and a lot of other work underneath his car; his practice would be to lay on the ground in a ditch in his yard to work underneath his car at home.[32] He estimated using half a can of the Liquid Wrench over the weekend working on his car.[33] He reported that during the summer months, a pint container of Liquid Wrench would last him a couple of weeks since he would be working on his dad's car, his own car, and that of his buddies.[34] He reported that the ends of his fingers would crack open when he was using Liquid Wrench as a younger man when he was working on cars.[35]

Mr. Rhyne recalled using Kutzit while working on cars with his father around ages 14-15; he would use it to scrape valve cover gaskets or oil pan gaskets with a putty knife.[36] He would use a brush to apply the Kutzit on the gasket, which would take 30 minutes to apply on both gaskets of the valve covers.[37] Scraping the gaskets took over an hour.[38] Mr. Rhyne recalled that after July of 1976 when he went to Duke and started working in the fab shop, right up until the time he left the fab shop in 1980, he still worked on his cars at home to some extent.[39]

DUKE – MCGUIRE NUCLEAR STATION, HUNTERSVILLE, NORTH CAROLINA, 1976-1983

Mr. Rhyne began working for Duke at the McGuire Nuclear Station in April 1976 and worked for Duke until May 23, 2015, when he stopped working due to being diagnosed with Leukemia.[40] He worked at the facility from the time it was under construction until it went online.[41]

When he first went to work at Duke at the McGuire facility, his job title was called utility and he worked doing the railroad track for 3 months outside, which involved building a railroad track on the Duke property for equipment delivery; he didn't recall having used any chemical products while he was involved in building the spur.[42] After working as utility for 3 months, he next started working in the pipe fab shop from 1976 to 1980.[43] From 1980 to 1983, he worked out of the pipe fab shop out in the plant doing manual labor as a pipefitter installing rupture restraints and pipe supports; he reported that during this time, there was a lot of piping installed and he was involved

[30] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 21.
[31] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 259.
[32] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 198, 256.
[33] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 258.
[34] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 259.
[35] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 27.
[36] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 316-319.
[37] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 321.
[38] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 321-322.
[39] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 262.
[40] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 45, 247.
[41] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 46.
[42] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 48, 68-69.
[43] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 49, 57, 69.

in supporting the pipe.[44] Mr. Rhyne worked 8-hour days.[45] He spent half of his day in the pipe fab shop cleaning material or cutting pipe and the remaining 50% bending pipe.[46]

While working in the pipe fab shop, Mr. Rhyne reported that his tasks involved building pipe (stainless steel and carbon) sub-assemblies to send up to the power plant for ready installation; this involved cutting pipe and beveling them and bending them.[47] For beveling, he would use a small low speed lathe to put the bevels on the edges of pipes and couplings.[48] There was also a one arm bandit saw to saw the pipes.[49]

There were 8 bays in the pipe fab shop; Mr. Rhyne reported that out of the 8-hour per day/40-hour week, he spent 50% of his time cleaning parts in the Safety-Kleen parts washer in the fab shop.[50] He wore rubber gloves while using the Safety-Kleen parts washer; he recalled that he was still in contact with the solvent above his wrist and even his hands as he immersed his hands into the washer.[51] There could be up to 12 people working in the pipe fab shop at any given time during the 1976 to 1980 timeframe.[52]

He reported the size of the pipe fab shop: it was about 100 feet long by "maybe 50 foot wide" with no windows; there were rolling doors on each end of the shop that would be left open during the summer and closed in the winter.[53] He recalled having to step outside when the doors were closed since ventilation was not good.[54] Mr. Rhyne reported that the ventilation in the pipe shop wasn't good particularly during winter and he recalled having to sometimes go outside to take in fresh air because he would have difficulty breathing.[55] He recalled overhead exhaust fans mounted to the ceiling in the fab shop, about 30 feet up; he didn't know how many there were.[56] He reported that there may have been one or two pedestal type fans for cooling during the summertime in the fab shop.[57]

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[44] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 69-70, 81.
[45] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 58.
[46] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 600-601.
[47] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 52.
[48] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 51-52.
[49] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 52.
[50] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 61, 602.
[51] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 713-714.
[52] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 279.
[53] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 59-60.
[54] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 59-60.
[55] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 59.
[56] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 59-61, 269, 281.
[57] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 280.

Product Use in the Pipe Fab Shop

Mr. Rhyne reported having used Liquid Wrench and the Safety-Kleen parts washer in the pipe fab shop. He also reported that he sometimes used a product called Spotcheck to clean some of the piping and reported, "but it was very little"; he recalled that it was an aerosol can that he would spray on and wipe off.[58]

Besides having rubber gloves at the Safety-Kleen parts washer, other personal protective equipment he wore at Duke during the 1976 to 1983 timeframe included hard hat, safety glasses, and leather gloves when he needed them; steel-toed boots became a requirement in the early 2000s timeframe.[59] He also reported wearing face shields for grinding and brushing work but not chemical product use.[60] Also, he reported that if he was working on cutting or beveling the pipes, he didn't wear gloves since it could get caught up in the rotating piece of equipment.[61]

Liquid Wrench

He recalled using Liquid Wrench during the 1976-1980s timeframe in the pipe fab shop.[62] He would be using the low speed small lathe; so he would use one hand to run the tool while the equipment was turning and the other hand to continue squirting the Liquid Wrench – he wouldn't continuously be shooting out a stream.[63] He could work on piping with up to a 4-inch diameter and 3/4 of an inch thick.[64] Regarding how often he used Liquid Wrench while working in the pipe fab shop, he reported "a bunch because we sawed and sawed and sawed piping."[65]

Mr. Rhyne would use the Liquid Wrench as he was cutting bevels on pipe and couplings on the lathe – he would have to continue to lubricate with the Liquid Wrench the part he was cutting to prevent the stainless pipe from chipping or the bit from tearing.[66] He reported, "one hand I had to run the tool end, and the other hand I had the … Liquid Wrench. And you just continuously use it until you – you get the bevel done. And that would take a lot of time to do that."[67] He reported that he did other jobs in the pipe fab shop other than just cutting bevels on pipe and couplings.[68] He recalled that when he was beveling couplings, and especially couplings and the heavy wall

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[58] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 73-74.
[59] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 75.
[60] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 158-162.
[61] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 54-55.
[62] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 57.
[63] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 58-59.
[64] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 58-59.
[65] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 73.
[66] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 261.
[67] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 261.
[68] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 264.

piping, he would go through at least two 16-ounce cans in a day.[69] On average, he reported using 6 cans of Liquid Wrench a week in the pipe fab shop.[70]

One day a week he might be bending pipe and didn't at that time use any Liquid Wrench in the pipe fab shop.[71] He recalled that the couplings and the pipe would get hot as he was cutting on the lathe and that the Liquid Wrench would cool it off and reported, "it would get warm enough that when I took it out of the chuck he would have to use a rod or something and set it down."[72] He didn't use gloves while cutting on the lathe for safety reasons.[73]

While using Liquid Wrench at Duke, he would get it on his hands "quite a bit" and some on his arms; he would squirt Liquid Wrench in one hand and lubricate as he was cutting the bevel with his other hand on the rotating lathe.[74] His hands were about a foot away from his face.[75] He would only wash his hands during his two 15-minute breaks.[76] He recalled that his fingertips would crack during this timeframe.[77] Duke did not provide uniforms and he wore his own clothes to work; long sleeve during the winter and short sleeve during the summer.[78]

Safety-Kleen Parts Washer

Mr. Rhyne reported that there was a big area out back of the pipe shop outside – gravel type dirt parking lot where piping would be received from the warehouse; he would then go to this area to pick out the necessary pipe that would be requested by the plant.[79] He would use the Safety-Kleen parts washer to wash the pipe parts after he retrieved from outside.[80] He reported using gloves while working with the parts washer and recalled that when he used the parts washer, some of the solvent would get on his hands.[81]

Spotcheck

He reported sometimes having used Spotcheck in the pipe fab shop to clean before inspections. No further information was provided.[82]

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[69] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 264.
[70] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 265-266.
[71] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 264.
[72] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 268.
[73] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 268, 271.
[74] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 308-311.
[75] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 310.
[76] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 310-311.
[77] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 312.
[78] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 313.
[79] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 52-53.
[80] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 53, 598-599.
[81] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 599-600.
[82] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 277-278.

Mr. Rhyne stopped working in the pipe fab shop around 1980.[83]

Pipe Supports —1980-1983

After working in the pipe fab shop, Mr. Rhyne worked on pipe supports. There would be other trades working around Mr. Rhyne including welders, millwrights setting equipment, iron workers setting iron, as well as instrumentation and electrical workers.[84]

The majority of his work involved installing pipe supports with the majority requiring baseplates.[85] In any given time, there would be 4 or 5 crews doing this with an average of 8 per crew.[86] He reported the type of tools he used in putting pipe supports included saws, porta bands, and one arm bandit saws.[87] He recalled that they didn't use any chemicals while using a porta band since it took two hands to run the porta band.[88] He reported that they tried to use the porta bands as much as they could in the plant.[89]

Product Use in the Pipe Supports

Liquid Wrench

He would use Liquid Wrench on the saw blade; he reported that in sawing tube steel/pipe, if it was big enough and thick enough to use the one arm bandit, he'd take it to the pipe fab shop and cut it and take it back up in the plant; he'd use Liquid Wrench on the saw blades in the shop.[90] He used Liquid Wrench since it was a good lubricant and would keep the saw from tearing the teeth and the blades.[91] After he left the fab shop in 1980, he reported that several times he would take equipment such as pipe supports or tube steel back down to the fab to make a cut and would use Liquid Wrench during this time.[92] He reported that he hardly used Liquid Wrench when he was doing pipe supports in the plant.[93]

Tap Magic/Rapid Tap

Mr. Rhyne used Rapid Tap or Tap Magic while drilling holes in metal ice plates that were used for pipe supports.[94] It was a lubricant for metal.[95] Tapping was done in the machine shop,

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[83] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 255.
[84] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 84-85.
[85] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 87.
[86] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 88.
[87] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 70.
[88] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 72.
[89] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 73.
[90] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 71.
[91] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 71-72.
[92] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 307.
[93] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 73.
[94] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 334, 630.
[95] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 334-335.

fabrication area which was 20 by 25 feet.[96] He used it to keep what he was tapping lubricated so he would lubricate as he tapped to keep from breaking the tap off in the hole.[97] He reported that a lot of times, they would be installing baseplates on concrete walls and would have to drill through rebar and would have to use Rapid Tap/Tap Magic during this process.[98] He didn't recall using gloves with Rapid Tap/Tap Magic.[99] During this time that he was primarily doing pipe supports, he recalled doing a lot of baseplate installations on ceiling and wall concrete – in which he would be cutting the supports with power saws and would use Rapid Tap/Tap Magic unless he went to the pipe shop to cut bigger pieces.[100] The plant was not online at this point.[101]

Mr. Rhyne applied the Tap Magic/Rapid Tap out of the 16-ounce can with a straw on the nozzle; he would make four holes per plate and would take him 10 minutes to drill one hole – he would squirt the can at least 15 times per hole as he was drilling.[102] Regarding how often he used the tapping lubricant, he reported at least 20% during a given week from 1985 to 1991/1992 timeframe.[103] He reported sometimes wearing leather gloves while using Tap Magic and that his gloves would get wet.[104]

Varsol

Mr. Rhyne recalled using Varsol during the early 80s around 1980-1981 at Duke while working on the pipefitting crew to clean items such as bolting and fasteners.[105] He recalled going to the painters at Duke to get the Varsol; they would pump it out of their barrel into an open pail that he would carry back to his work station.[106]

He reported that in a week's time, he would probably go twice a week to the painters to get another pail of Varsol when it got dirty.[107] They would place the fasteners/bolts into the pail to clean them.[108] He would soak the items for about 30 minutes before brushing.[109] He would not wear respirator while using Varsol and would use his leather gloves to retrieve the items in the pail of Varsol and recalled that he would change his gloves quite a bit during a week's time.[110]

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[96] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 342, 643-644.
[97] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 334.
[98] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 81.
[99] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 82.
[100] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 82-84.
[101] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 84.
[102] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 630-632.
[103] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 632.
[104] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 342, 641.
[105] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 542-544.
[106] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 544-546.
[107] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 547.
[108] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 548.
[109] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 548.
[110] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 549.

The McGuire facility was completed in 1983 upon which Mr. Rhyne was transferred to the Catawba Nuclear facility.[111]

DUKE—CATAWBA NUCLEAR, YORK, SOUTH CAROLINA, 1983—1986/1988 TIMEFRAME

Mr. Rhyne transferred to Catawba in 1983, which was also a new construction.[112] Sometime in the 1986 to 1988 timeframe, Catawba came online.[113] While Catawba was his permanent location, he reported the he went back to McGuire and Oconee facilities on several occasions.[114] From 1983 to January 2015 he was based at the Catawba facility.[115]

When he first got to the Catawba facility, he was still classified as a pipefitter, hanger support mechanic.[116] During this timeframe, particularly around 1985, he started having to provide traveling support to other sites during outage such as that of the McGuire facility and the Oconee facility that were going or already online.[117] His home base was still the Catawba facility during this time.[118]

From 1983 to the late eighties, Mr. Rhyne continued to have the title of pipefitter and then subsequently became a powerhouse mechanic; in terms of job duties as a powerhouse mechanic, he reported that he was responsible for maintaining the plant, which included tasks such as maintenance on ice condensers, maintenance on heat exchangers, and scheduled preventative maintenance on various equipment.[119]

There was a period of time where he was in the construction division, which was until about 1991; he had a title that included pipefitter; and in 1991 there was a shift into a maintenance division.[120] When his job duties transitioned from construction division to maintenance division, his actual job duties changed from fitting pipe or installing hangers to that of maintaining equipment because at this point in time, the power plants were up and running and online.[121] When he went down to Catawba in 1983, he was on pipe supports and then left pipe supports at some point in time and started doing work on spring can hangers – adjustment and installation, which is another part of the load on pipe; he would be involved in doing load cell analysis on

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[111] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 88.
[112] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 68, 94.
[113] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 94.
[114] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 129.
[115] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 90.
[116] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 93.
[117] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 93.
[118] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 93.
[119] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 149-151.
[120] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 194.
[121] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 195.

pipe; after this job, he subsequently went back to start supporting outages like at McGuire and Oconee.[122]

Product Use at Catawba Facility

During the 1983 to 1988 timeframe, Mr. Rhyne reported using Kroil and CRC at the Catawba facility.[123] He also recalled having used the Safety-Kleen parts washer at Catawba with rubber gloves.[124]

He recalled that he used CRC from 1985 to 1990s "and up to maybe 2000" timeframe and recalled that it was originally an aerosol but that Duke switched to pump sprayers; CRC was used to clean equipment and tooling.[125] He recalled that one piece of equipment would have "like 288 nuts, 144 studs, 288 washers" and that some days they would use it all day long and that all of the equipment they cleaned had to be inspected by the QA Department with a fine cloth, white glove.[126]

Safety-Kleen Parts Washer, Zep Product and CRC

At Catawba, Mr. Rhyne used a Safety-Kleen parts washer; he recalled there were three each located in the machine shop, the hot shop, and upstairs above the shop.[127] Besides Safety-Kleen, during the 2000 timeframe, he recalled Zep was used in the washer.[128] Before 1998 when he became a supervisor, if he had occasion himself to wash a part, he could be at the parts washer all day but reported that parts washing wouldn't be a daily occurrence.[129] He reported, "there was plenty of equipment that required parts washing.[130] Once he became a supervisor, he reported that he mostly had other workers use the parts washer.[131] There was always rubber gloves available for use at the parts washer.[132]

As a supervisor, he reported that in the early 1998 to mid-2000 timeframe, he was more involved with his work and that he would wear gloves to observe and ensure parts were cleaned to pass inspections; he would observe the parts while they were in the parts washer as well as outside of the parts washer.[133]

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[122] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 94-95, 407.
[123] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 95.
[124] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 102.
[125] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 153-155.
[126] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 154.
[127] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 165-166.
[128] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 166.
[129] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 169-170.
[130] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 170.
[131] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 166-167.
[132] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 167.
[133] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 384-386.

Mr. Rhyne recalled that at some point in the 2000-timeframe from about 2005 to 2008 when he was a supervisor, Duke went from using Safety-Kleen to Zep.[134] He recalled that Zep was used in the parts washer that was located in the radiation control area (RCA) in the hot machine shop of the Catawba, McGuire, and Okonee plants in which he supervised during this timeframe of 2000s.[135] RCA was a precautionary area that was not contaminated and in which extra precautions would be taken in opening systems.[136] There would be an RCA for each unit within each power plant; with the exception of Oconee, which had 3 units, there were 2 units in the other Catawba and McGuire nuclear facilities.[137] The RCA was at least 60 yards by 50 yards wide with 10-14 feet ceiling varying across the space.[138] He reported that his crew did work at one time or another in each of the RCAs in each of the power plants.[139] This work involved preventative maintenance on various components every 3 months, 6 months or yearly basis; work in the RCA occurred both during outages and during operations.[140] Mr. Rhyne reported that between Catawba and McGuire, there were two units in each site with two ice condensers per unit that he would have to work an outage every 18 months from 1985 timeframe.[141]

As a maintenance mechanic in Catawba from 1991-1998, his job tasks included maintaining ice condensers, maintaining heat exchangers, doing preventative maintenance on equipment, and cleaning parts and tools.[142] In doing preventative maintenance on equipment from Catawba during the 1991/1992 to 1998 timeframe, he would be cleaning and inspecting both equipment and parts that were part of the equipment.[143]

He would use the Safety-Kleen parts washer and CRC to clean parts – nuts, bolts, washers; all these parts would be less than an inch.[144] He would use the CRC or the Safety-Kleen parts washer depending on convenience; he reported that some components had 288 nuts, 144 washers, 72 studs, and that some components could be 2 feet long and have 8 bolts in which case he would just use CRC to clean them.[145] He recalled cleaning nuts with CRC – one nut at a time.[146] The number of workers on these types of jobs could be from 3-10 people.[147] The CRC was in an aerosol can.[148]

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[134] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 374.
[135] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 360-362.
[136] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 367.
[137] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 368.
[138] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 368.
[139] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 368.
[140] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 369.
[141] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 297.
[142] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 427.
[143] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 430.
[144] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 430-432, 436.
[145] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 431.
[146] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 432.
[147] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 432.
[148] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 436.

He described how he used CRC to clean bolts, washers and nuts: he would lay a rag on his toolbox and take one nut at a time with a rag, spray on the CRC onto the bolt/washer/nut and wipe it off.[149] He would spray a single time for about a second and then wipe clean and if it was still dirty wash it again.[150] He reported that a washer cleaned up easier because it was flat and that a threaded nut took longer because of the threads.[151]

On an average day he reported using CRC to clean 30 bolts, washers or nuts.[152] For cleaning the end bell flanges with CRC, he would use a Scotch Brite pad to scrub it in certain areas; the average surface of a flange that he would clean with CRC was a three-quarter inch wide surface and on average would apply the spray on a flange about 20 times, 1-2 seconds per spray while scrubbing after each spray.[153] For cleaning the end bell with CRC, he would spray then scrub with Scotch Brite pads; on average he would do 40 sprays per end bell with a second or 2 for each spray.[154]

He reported that he would have to clean an end bell each time he was assigned to maintain a piece of equipment; on average, there were 2 end bells per piece of equipment.[155] On average he could "PM" [preventative maintenance] 3 pieces of equipment or 1 piece of equipment that was a lot larger; during a given week he could have 10 components/equipment that he would have to do preventative maintenance on.[156]

Regarding equipment he would clean, he reported that every tool in RCA had to be wiped down prior to returning it back to the RCA toolroom; it could be ratchets, combination wrenches, pipe wrenches, and X wrenches in which he would use CRC to clean.[157] He would also use CRC to clean heat exchange components such as the tubes, flanges associated with the end bells from heat exchangers as well as the end bell itself.[158] There were normally 2 end bells on heat exchangers and "hundreds and hundreds of heat exchangers at Catawba.[159] He reported that they would normally have 5 heat exchangers to repair and or clean per week; the dimension of the end bells varied from 6 inches to 6 feet.[160] He reported that they typically used CRC to clean anything they couldn't take to a parts washer.[161] Anything above 8 inches on the end bell would not be cleaned on a parts washer and instead CRC was used; he reported 50/50 regarding the percentage of the

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[149] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 498.
[150] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 500.
[151] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 500-501.
[152] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 501.
[153] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 502-503.
[154] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 504-505.
[155] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 505.
[156] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 505.
[157] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 439.
[158] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 439-441.
[159] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 441.
[160] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 442.
[161] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 443.

end bells that were cleaned in a parts washer as opposed to with CRC.[162] He reported that 30% of flanges were cleaned in the parts washer with the remainder flanges cleaned with CRC.[163]

On the occasions when he would wash a nut or bolt or a washer with a CRC product, he would be single handedly washing each part separately; if he was using the parts washer, he would let the parts all soak in there and would then wash each part individually one at a time.[164] The percentage of nuts and bolts and washer that he cleaned during the period of 1991/1992 to 1998 in a parts washer versus CRC was 70% due to convenience.[165] Regarding division of labor during preventative maintenance tasks including cleaning parts, he reported that one guy would be cleaning everything up and the other guy could be either tearing apart or putting back together or getting components or equipment signed off by QA.[166]

He reported that there had been hundreds of different pieces of equipment at Catawba in which he performed maintenance on between 1991-1998.[167] The duration of equipment maintenance depended on the size of the stationary equipment and ranged from 2 – 3 hours to 8 hours across all three buildings in the facility including the turbine building, auxiliary building, and reactor building.[168] He recalled there were exhaust fans and ventilation in the auxiliary building and that the turbine building was ventilated.[169]

He reported that 30% of his 8-hour day as a preventative maintenance mechanic, would be spent cleaning parts including bells and flanges at the parts washer.[170] There was no parts washer in the reactor building; he used the parts washer in the auxiliary and turbine buildings; he recalled having used the parts washer in the auxiliary building 20% more than the one in the turbine building since the equipment in the auxiliary building was a lot larger so more bolts and end bells.[171]

The percentage of radiation work permits (RWPs) that he worked on requiring the use of a respirator was 5%.[172] In addition, these RWPs called for safety glasses and certain dress requirements that included cloth coveralls, rubber or cotton gloves, rubber shoe covers, plastic

[162] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 444-445.
[163] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 445.
[164] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 474.
[165] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 475.
[166] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 484-485.
[167] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 448.
[168] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 450-451.
[169] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 489, 492.
[170] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 611.
[171] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 619-620.
[172] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 448-449, 453.

shoe covers and also cloth head cover.[173] He reported that only 10% of the time that he did preventative maintenance at Catawba between 1991 and 1998 required these safety equipment.[174]

Kutzit

Mr. Rhyne only used Kutzit at Duke during the maintenance timeframe of his work in the 1985 timeframe and not while working in the pipe fab shop.[175] He used Kutzit at Duke to remove Garlock gaskets from flanges; he estimated using Kutzit 30% of the time in a month timeframe.[176] He recalled that 1 hour of the 3 hours cleaning gasket material would be spent using Kutzit by applying it with a brush.[177] He didn't use any personal protective equipment during use.[178]

Marvel Mystery Oil and Kroil

Mr. Rhyne reported using marvel mystery oil when performing maintenance on ice condensers; the ice condensers had 1944 ice baskets that were 12 inches in diameter and 48 feet long; the tech spec required a certain amount of weight of ice in these baskets so they would go in and weight them; if the weight didn't meet the specs to ensure there would be enough for the next 18 months, engineering would pick the baskets to unload and he would use vibrators to unload those baskets; he would use marvel mystery oil to lubricate the vibrators in an air header that went 300 degrees around the inside of the reactor building.[179] Mr. Rhyne recalled using Kroil during the early 90s till 1998 timeframe.[180] He reported having used Kroil to break down vibrators prior to outages and to go through their equipment to ensure they were ready for outage work.[181] They would use Kroil to break apart ice condenser vibrators – there were 70 some vibrators; they would apply the Kroil oil to the vibrator where it joined together and lubricated that area so it would break apart.[182] During a 40-hour week, they would break apart 15 vibrators per day, and would use Kroil during an entire 10-hour day while breaking apart the vibrators.[183]

DUKE - ALLEN STEAM PLANT IN BELMONT, NORTH CAROLINA

This was a coal fired plant that was online; he worked here for a 4-month timeframe from September to December of 1987.[184] He did repair and maintenance type work cutting pipe

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[173] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 453, 455-456.
[174] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 456.
[175] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 323.
[176] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 667.
[177] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 669.
[178] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 328.
[179] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 425-426; 674-677.
[180] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 675.
[181] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 426.
[182] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 677.
[183] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 678.
[184] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 89, 111.

systems out and tearing down precipitators.[185] He didn't recall ever using a chemical product at the Allen Steam Plant.[186]

DUKE—CLIFFSIDE STEAM PLANT, CLIFFSIDE, NORTH CAROLINA

This was a steam plant.[187] He worked here for a month in April of 1985 doing maintenance repair work as a pipefitter; he recalled having used a chemical to remove bolting while repairing coal bunkers; he didn't recall the name of this product but reported spending at least two hours to two and one-half hours and a half day in a typical 8-hour day.[188]

DUKE—OKONEE PLANT, SENECA, SOUTH CAROLINA

This was a nuclear plant; he worked here from December 1986 to February 1987.[189] His tasks were considered maintenance repair work; he was involved in outage work on heat exchangers and steam generators.[190]

Every 18 months, he would work in the reactor building during an outage.[191] This involved doing maintenance on ice condensers; there were 1944 ice baskets that they would have to weigh to tech spec requirements.[192] Regarding how often an outage would last, he reported that different outages had different durations from 18 days to 30 days.[193] The first time he worked an outage in the reactor building was 1985, with 1988 being the last time he worked an outage, and 2015 being the last time his team worked on outage when he was a supervisor.[194]

An outage is when the unit would be offline for work; there wouldn't be power generated.[195] Although not every outage, he would work 1-2 weeks before an outage while the unit was online; he would wear a respirator and a cold suit.[196] During the course of his career, he reported having gone into the reactor building while it was online 2-3 times.[197]

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[185] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 111-112; 229-230.
[186] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 113.
[187] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 286.
[188] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 113-115.
[189] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 115.
[190] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 115, 419.
[191] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 291.
[192] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 292.
[193] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 292.
[194] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 293-294.
[195] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 295.
[196] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 295.
[197] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Pages 296-297.

EXPOSURE ASSESSMENT

Exposure to benzene by product/Operation

Savogran – Kutzit

During certain years Kutzit was manufactured with benzene as an ingredient. For example, Kutzit KT-F252-E63 was reported to contain 254 gallons of benzene in a total liquid volume of 456 gallons (approximately 56% benzene by volume). Kutzit K 202 contained 256 gallons of Benzasol (90% benzene, 10% acetone), 69 gallons of methanol and 132 gallons of solvent blend, for an approximate benzene content of 53%. A document prepared by Sandia Laboratories, printed June 1978, titled Product Identification Fil Compiled and Edited by Charles E. Gray, 3311 Chemistry Laboratory, reports that Kutzit paint stripper contained more than 15% benzene. Other Kutzit formulations contained Toluene (Toluol) at approximately 27% to 46% by weight. As Toluene has been reported to contain from 1,000 to 10,000 parts per million (ppm) benzene, these Kutzit formulations also contained substantial benzene concentrations.[198]

Mark Monique testified on behalf of Savogran, the manufacturer of Kutzit. Mr. Monique did not begin his employment with Savogran until 1987. Mr. Monique stated that he spoke with Tom Little to learn the company's history prior to 1987.[199] Mr. Little started with Savogran in 1972 as general factory help. Mr. Monique testified that he "knew for certain" that Tom Little did not have knowledge of what chemicals were going into Kutzit.[200] No other persons employed by Savogran in the 1960s and 1970s are still alive.[201] Mr. Monique testified that it was his understanding that benzene was used as an ingredient in Kutzit from 1963 to at least 1973. Savogran produced a November 16, 1973, formula that listed methylene chloride in place of benzene.[202] Mr. Monique, however, did not know when after November 16, 1973, this formula was first actually used by Savogran.[203] Savogran inventory records indicate that the blend of benzene and acetone was used until February 28, 1974.[204] Mr. Monique therefore did not have personal knowledge of when benzene was removed as an ingredient from the Kutzit product and did not appear to have spoken with anyone who had worked for Savogran during the 1960s and 1970s with knowledge of the chemical contents of the product.

A draft Kutzit label dated August 27, 1973, listed methylene chloride and toluol and did not list benzene.[205] A Savogran advertisement dated August 13, 1973, referred to Kutzit as "Paint

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[198] Document Production, Kutzit Formulas.
[199] Deposition of Mark Monique, Dated July 21, 2016, Pages 35 – 36.
[200] Deposition of Mark Monique, Dated July 21, 2016, Page 82.
[201] Deposition of Mark Monique, Dated July 21, 2016, Page 82.
[202] Olson CO, "New Kutzit H-103A". The Sabogran Company, November 16, 1973.
[203] Deposition of Mark Monique, Dated July 21, 2016, Pages 56 – 57.
[204] Lee-Savogran-000094; Deposition of Mark Monique, Dated May 7, 2019, Page 106.
[205] Savogran Label, 1973. "Kutzit® Paint Remover", August 27, 1973.

Remover Liquid-Benzol".[206] Savogran advertisements from January 1, 1974, August 2, 1976, April 4, 1977, February 10, 1978, and July 1, 1979, referred to Kutzit as "Liquid Type Paint and Varnish Remover".[207,208,209,210,211] In 1985 Savogran advertised that Kutzit "does not contain benzol (benzene)".[212] On June 16, 1977, Carl O. Olson, president of Savogran wrote to S. John Byrington, Chairman of the Consumer Product Safety Commission with reference to the "Clinical Toxicology of Commercial Products" 4th Edition by Williams & Hilkins, which listed Kutzit as containing benzol. Mr. Olson claimed that "[w]e have not used Benzol for some years and advised the University of Rochester again in July 1976."[213] There was also reference to Toluol being used in Kutzit instead of Benzol. Thus, there is conflicting information as to when benzene was removed from Kutzit as an ingredient.

In a 1978 investigation, Young et al. reported a series of 5-minute air samples ranging from 73 to 225 ppm benzene (average 130 ppm for the 25 minute period) when a Kutzit formula containing 52% benzene by volume was used for paint stripping.[214] These samples were taken in a two-car garage with an overhead door that was opened intermittently.

As there is no measured exposure information in the record on outdoor use of Kutzit (as Mr. Rhyne used it at home helping his father work on vehicles), the exposures associated with this use of Kutzit can be estimated using the Advanced Reach Tool (ART) developed through the Registration, Evaluation and Authorization of Chemicals, commonly referred to as REACH.

This is a comprehensive regulation on chemicals developed in the European Community. Among the many regulatory requirements under REACH is the need for companies to complete chemical exposure and risk assessments for chemicals they sell or import into the EU. In support of the implementation of the REACH regulations, the Advanced Reach Tool (ART) is the occupational exposure modeling tool that was developed by a consortium of industry, academia, and government to assist companies in complying with the new REACH requirements for worker exposure assessments. The Advanced Reach Tool V 1.5 (ART) (www.advancedreachtool.com)

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[206] Savogran Advertisement, 1973. "Distributor Net Unit Cost List in Conformity with Phase IV" Savogran. Norwood, Massachusetts. August 13, 1973.
[207] Savogran Advertisement, 1974. "Distributor Net Unit Cost List in Conformity with Phase IV" Savogran. Norwood, Massachusetts. January 1, 1974.
[208] Savogran Advertisement, 1976. "Distributor Net Unit Cost List" Savogran. Norwood, Massachusetts. August 12, 1976.
[209] Savogran Advertisement, 1977. "Distributor Net Unit Cost List" Savogran. Norwood, Massachusetts. April 4, 1977.
[210] Savogran Advertisement, 1978. "Distributor Net Unit Cost Prices" Savogran. Norwood, Massachusetts. February 10, 1978.
[211] Savogran Advertisement, 1979. "Distributor Net Unit Cost Prices" Savogran. Norwood, Massachusetts. July 1, 1979.
[212] Savogran. Advertisement, 1985. "Savorgran Kutzit®, Liquid Paint & Varnish Remover". Savogran, Norwood, Massachusetts.
[213] Letter to S. John Byrington from Carl O. Olson. *Kutzit Paint & Varnish Remover*. June 16, 1977.
[214] Young RJ, Rinsky RA, and Infante PF. 1978. Benzene in Consumer Products. *Science*, 199:248-248.

incorporates a mechanistic model that uses determinants of exposure. To calculate estimates of inhalation exposure in ART, the user identifies determinants of exposure in the work environment and incorporates them into the model. Examples of these model inputs include the sources of the exposure, the task being performed, the rate at which the tasks are conducted, certain physical properties of the agent, the environment in which the exposures occur, and exposure controls applied. The inputs are mostly categorical, e.g., the user selects from a menu items such as spraying, filling containers with liquids or wiping a surface down with a solvent. There have been numerous peer-reviewed journal articles discussing using the ART tool, and it is finding widespread acceptance as a method for estimating exposures. The inputs for the ART V1.5 model used to calculate exposures experienced during working with mineral spirits are calculated using workplace characteristics, including the chemicals used, the controls in place and the tasks performed by the worker. The ART model incorporates real-world measurements to "calibrate" the exposure estimates it produces.

In modeling Mr. Rhyne's benzene exposure from use of Kutzit working outdoors on vehicles with his father, I conservatively estimated that Mr. Rhyne used Kutzit one-third of the times he worked on the family cars. The results of the ART model for using Kutzit containing 50% benzene outdoors for a 90-minute period are 62 milligrams per cubic meter (mg/m^3) median, interquartile confidence interval is 47 mg/m^3 to 84 mg/m^3; this is 19.5 ppm (14.8 – 26.4 ppm) for a 90-minute period. The daily average for an 8-hour period is [(19.5 ppm) (90 min) + (0) (390 min)]/480 min = 3.66 (range 2.78 – 4.95 ppm). If he used Kutzit one day in three when he worked on cars, and he worked on cars one day per month, his daily average exposure over each year was 0.04 ppm (range 0.03 – 0.06 ppm). The reports of the ART models including input and output values from the models are included in the Appendix.

Liquid Wrench

The product named Liquid Wrench was manufactured by the Radiator Specialty Company starting in 1941. The nonaerosol formulations of Liquid Wrench contained approximately 88% raffinate and 12% naphthenic oil.[215] Raffinate was produced by United States Steel (USS) as a byproduct of coke oven operations. It was described as a water-white liquid with an aromatic odor. The benzene content of raffinate varied from 1 to 14% by volume, with an average of 3 or 5% by volume.[216]

Other documents provide information on the benzene content of Liquid Wrench. A material specification sheet for raffinate from USS dated September 7, 1977, reports chemical analysis of

[215] Williams PRD, Knutsen JS, Atkinson C, Madi AK and Paustenbach DJ. 2007. Airborne Concentrations of Benzene Associated with the Historical Use of Some Formulations of Liquid Wrench. *Journal of Occupational and Environmental Hygiene,* 4:547-561.

[216] Williams et al., 2007, previously cited.

5% benzene in raffinate.[217] A memorandum to M.H. Meyning and J.L. Wescoat dated October 4, 1977, reports analytical results of 30% benzene content by volume in Liquid Wrench.[218] Interoffice correspondence in the form of a memorandum from W.T. Gregg dated October 10, 1977, conveyed this finding of 30% benzene content in Liquid Wrench and included the statement that "We feel use of this material should be discontinued."[219] A document from the Technical Service Laboratory dated October 18, 1977, references the Gregg memorandum of October 10 and reports the laboratory analysis of Liquid Wrench purchased at a local store. This sample was reported to contain 7% benzene by volume.[220] An interoffice memorandum from C.W. Williams dated November 29 1977, conveys the analytical result that Liquid Wrench was found to contain 30% benzene and states that "...you may want to replace Liquid Wrench with a low-benzene content material."[221] A laboratory report dated March 24, 1978, states that the standard formula for Liquid Wrench has been manufactured for many years using drip oil (raffinate) containing up to 14% benzene. Table 1 in this report shows the benzene content of raffinate to be 1 to 14% with an average of 3%.[222] A memorandum from Jim Wells dated March 30, 1978, reports that the benzene-containing Liquid Wrench has been replaced, and the existing supply of raffinate will be exhausted by the end of April 1978.[223]

Mr. Rhyne used Liquid Wrench in two different ways. In his work on vehicles at home, in school and at Setzer's, he used Liquid Wrench as a penetrating oil to help loosen rusted parts. At Duke Power, he used Liquid Wrench as a coolant and lubricating fluid while machining metal parts. This included beveling and cutting steel pipe, hangers, and other parts.

The exposure scenario for his use of Liquid Wrench at home, in school and at Setzer's is comparable to published reports on benzene exposures from Liquid Wrench use under a range of conditions. Williams, et al. (2007) published a simulation intended to characterize exposures arising from typical uses of Liquid Wrench. For these experiments, a set of hydrocarbon blends was prepared to simulate Liquid Wrench formulations containing varying concentrations of benzene (range from 1, 3, 14, and 30 % benzene by volume). Other experimental variables were the effective ventilation rate in the room (low 1 to 3 air changes per hour; medium 5 to 12, high 20 to 60), the volume of reformulated Liquid Wrench applied to each part (10 or 20 milliliters), and the room air temperature.

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[217] United States Steel Corporation, 1977, *Material Specification: Raffinate (Drip Oil)*, September 7, 1977. (Ex. 83_USS 00039).
[218] Document Production, Ex.89_USS 02511.
[219] Document Production, Ex.90_USS 02512.
[220] Technical Services Laboratories, 1977, Analysis of Liquid Wrench, Princeton, New Jersey: Technical Services Laboratories, Mobil Technical Center. October 18, 1977. (Ex. 88_USS 02509-2510).
[221] Interoffice memorandum from C.W. Williams dated November 29, 1977. (Ex. 92_USS 02514).
[222] Laboratory Report, *Eliminate Benzene from Liquid Wrench No. 1 Standard Formula,* March 24, 1978. (Ex. 119 RSC_ 22-28).
[223] Memorandum from Jim Wells, *New Liquid Wrench Formula,* dated March 30, 1978. (Ex. 120 _ RSC 152).

The benzene air concentrations measured in the Williams et al. (2007) experiment are presented in the following table, which was prepared by extracting data from Tables II and III in the 2007 Williams et al. paper. For the 1% benzene Liquid Wrench formulation, eight air samples were collected, result was an average of 0.08 ppm for the 15-minute work cycle. Five of the exposure scenarios utilized the 3% benzene formulation, under varying conditions of ventilation and quantities of Liquid Wrench used. The 15-minute personal samples were collected for the 3% benzene formulation scenarios ranging from 0.11 to 1.38 ppm benzene. For the 14% benzene Liquid Wrench formulation, four scenarios were used; personal 15-minute samples were taken, with results ranging from 0.34 to 3.37 ppm benzene under widely varying ventilation conditions. For the 30% benzene Liquid Wrench formulation, one scenario was used, with a result of 3.79 ppm for a 15-minute personal sample taken under what the investigators described as a moderate air exchange rate (7.7 air changes per hour).

Table 1 Airborne Benzene Concentrations Measured in Simulations of Liquid Wrench Use (Williams et al. 2007)

Scenario	Benzene Content % Vol	Quantity LW ml	ACH Av	15-minute Personal (mg/m^3)	15-minute Personal (ppm)	1-hour Personal (mg/m^3)	1-hour Personal (ppm)	1-hour Area (mg/m^3)	1-hour Area (ppm)
1	1.00	10.00	6.90	0.20	0.08	0.10	0.04	0.05	0.02
2	3.00	10.00	7.50	0.80	0.31	0.60	0.23	0.49	0.19
3	14.00	10.00	5.70	4.40	1.69	1.70	0.65	1.86	0.71
4	30.00	10.00	7.70	9.90	3.79	6.80	2.61	5.05	1.93
5	3.00	10.00	6.80	0.90	0.34	0.70	0.27	0.61	0.23
6	3.00	10.00	1.70	3.60	1.38	2.20	0.84	1.17	0.45
7	3.00	10.00	32.00	0.30	0.11	0.20	0.08	0.10	0.04
8	14.00	10.00	2.20	8.80	3.37	8.20	3.14	3.68	1.41
9	14.00	10.00	63.00	0.90	0.34	0.60	0.23	0.38	0.15
10	14.00	10.00	outdoors	2.40	0.92	1.20	0.46	0.14	0.05
11	3.00	20.00	11.80	0.90	0.34	0.70	0.27	0.60	0.23

% Vol percent volume
LW ml Liquid Wrench milliliters
ACH Av air changes per hour average
mg/m^3 milligram per cubic meter
ppm parts per million

Source: Williams, et al. 2007. Airborne Concentrations of Benzene Associated with the Historical Use of Some Formulations of Liquid Wrench. *Journal of Occupational and Environmental Hygiene* 4:547-561, Tables II and III.

Another simulation study of Liquid Wrench with varying benzene concentrations was reported by Spencer in 2002.[224] The results of this simulation were comparable to those findings reported by Williams. The Spencer simulation reported that for Liquid Wrench formulations containing approximately 1% benzene, the 15-minute personal exposure levels ranged from 0.84 to 1.1 ppm (average 0.96 ppm). For Liquid Wrench formulations containing 7% benzene, the personal

[224] Spencer JW. 2002. Environmental Profiles, Inc. Report of Findings, Exposure Assessment: An Evaluation of Benzene from the Application and Use of a Prepared Liquid Wrench Solvent in Static Environmental Conditions. EPI Project No. 22472.

exposures ranged from 1.0 to 5.03 ppm benzene (average 2.42 ppm). For the 30% benzene Liquid Wrench, the personal 15-minute exposures ranged from 1.4 to 3.53 ppm, average 2.45 ppm.

Based upon the record in this case, it appears that the working conditions under which Mr. Rhyne used Liquid Wrench in work on vehicles at home most closely resembled scenario 10 that was work done outside. The only data for use of Liquid Wrench outdoors is scenario 10 from Williams et al. 2007;[225] using Liquid Wrench with 14% benzene, the 15-minute average exposure was 0.92 ppm; the 1-hour personal exposure was 0.46 ppm. In school and at Setzer's, the work appears to have been conducted in facilities with medium ventilation (garage doors that were opened), as was the case for scenarios 1 through 5 in the Williams et al. (2007) study. The average of the 15-minute benzene exposures in these scenarios was 1.24 ppm (range 0.08 ppm to 3.79 ppm). The average 1-hour personal exposure was 0.76 ppm (range 0.04 ppm – 2.61 ppm).

Under the exposure scenario for using Liquid Wrench as a coolant and lubricating fluid at Duke Power, Mr. Rhyne and his co-worker Mr. Couch described similar work practices. When using Liquid Wrench in the pipe shop in the 1976 to '80 timeframe, he would continuously squirt Liquid Wrench onto the rotating part (such as the coupling) that he was beveling.[226] Both Mr. Rhyne and Mr. Couch recall doing the beveling process on an average of at least one hour every day, a little over one hour a day, some days more. To keep a bit (the tool that did the beveling) cool you had to hit it (with Liquid Wrench) about every 15, 20 seconds for the duration of the cut. Both Mr. Rhyne and Mr. Couch recalled getting Liquid Wrench on the skin of both sides of their hands. Mr. Couch also recalled using Liquid Wrench on the blade of a saw. As there is no indication that the benzene, containing Liquid Wrench was recalled, I considered that Mr. Rhyne used Liquid Wrench from the existing supply until the end of 1978. The duration of his use in the Pipe Fab Shop therefore was from July 1976 until January 1979, a 2.5-year period.

Mr. Rhyne's inhalation exposures can be estimated during these work process steps using a modeling approach derived from the American Industrial Hygiene Association.[227] The predicted exposures resulting from the vaporization of the benzene in Liquid Wrench are calculated using the Near Field/Far Field (2 Box) model approach. This modeling approach estimates contaminant concentrations resulting from evaporation of liquid from a wetted surface.

This model has two general forms, one for estimating concentrations in the near field, which in this case was the distance from the tool (the beveling bit or the saw blade) to Mr. Rhyne's breathing zone, approximately 2.5 feet (0.75 meters). The second form is for the far field, which is distances greater than 0.75 meters from Mr. Rhyne.

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[225] Williams et al., 2007, previously cited.
[226] Deposition of Johnny Couch, December 7, 2017, Pages 57-58.
[227] American Industrial Hygiene Association. 2014. Mathematical Models for Estimating Occupational Exposures to Chemicals, 2nd Edition.

The near field model is presented here:

$$C_{NF}(t) = \frac{G}{Q} + \frac{G}{\beta} + G\left(\frac{\beta \cdot Q + \lambda_2 \cdot V_{NF}(\beta + Q)}{\beta \cdot Q \cdot V_{NF}(\lambda_1 - \lambda_2)}\right)\exp(\lambda_1 \cdot t) - G\left(\frac{\beta \cdot Q + \lambda_1 \cdot V_{NF}(\beta + Q)}{\beta \cdot Q \cdot V_{NF}(\lambda_1 - \lambda_2)}\right)\exp(\lambda_2 \cdot t)$$

here C is the near field concentration mg/m^3
G is the emission rate in milligrams per minute (mg/min)
Q is the ventilation rate

B is the exchange rate between zones = 1/2 (FSA) (S) where FSA is the free surface area of the near field geometry (in this case, 3.63 m^2) and S is the random air velocity at the near field-far field interface (in this case 3.6 m/min as reported by Baldwin et al. 1998).[228]

The far field model is:

$$C_{FF}(t) = \frac{G}{Q} + G\left(\frac{\lambda_1 \cdot V_N + \beta}{\beta}\right)\left(\frac{\beta \cdot Q + \lambda_2 \cdot V_N(\beta + Q)}{\beta \cdot Q \cdot V_N(\lambda_1 - \lambda_2)}\right)\exp(\lambda_1 t) - G\left(\frac{\lambda_2 \cdot V_N + \beta}{\beta}\right)\left(\frac{\beta \cdot Q + \lambda_1 \cdot V_N(\beta + Q)}{\beta \cdot Q \cdot V_N(\lambda_1 - \lambda_2)}\right)\exp(\lambda_2 t)$$

With the same units as the near field model.

The values for the input parameters to the model are derived from information provided by Mr. Rhyne about the rate at which he used Liquid Wrench during the beveling and sawing processes.

These values are summarized as follows:

Mr. Rhyne recalled that daily volume of Liquid Wrench he used varied, and on average he used 6 cans per week (1.2 cans per day). Each can of Liquid Wrench was 16 ounces. The number of hours per day he spent beveling varied as well, some days he did no beveling, other days he spent the entire 8-hour shift beveling. I used 4 hours per day as the midpoint for this modeling. So, if he used 1.2 cans per day (568 mL) over a 4-hour period, and the benzene content of Liquid Wrench was 5%, the benzene generation rate was 104.1 milligrams (mg) benzene per minute. For Liquid Wrench containing 3% benzene, the rate was 62.4 mg/min; for 7% benzene it was 145.6 mg/min.

The pipe fabrication shop was reported to be about 50 feet by 100 feet in plan with 10-14 feet ceilings (midpoint 12 feet), so the room volume was 1,719 m^3. Using a typical random air velocity of 3.6 m/min for industrial workspaces (Baldwin and Maynard, 1998) and a room air exchange rate of 5 air changes per hour, the air supply rate to the shop is 143 m^3/min.

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[228] Baldwin PEJ and Maynard AD. 1998. A survey of wind speeds in indoor workplaces. *The Annals of Occupational Hygiene*, 42(5):303-313.

The models for the time-weighted average (TWA) benzene concentrations predicted for the 4-hour period in mg/m^3 (ppm) are presented in the Appendix. Results are summarized in the following Table 2. I conservatively assumed that Mr. Rhyne was not exposed to benzene from Liquid Wrench during the remaining 4 hours of his shift, so his daily (8-hour) TWA was half the value calculated for the 4-hour periods.

Table 2 Benzene Exposures from Use of Liquid Wrench

Scenario	Median (50%) Benzene mg/m^3 (8-hour TWA ppm)	25% Benzene mg/m^3 (8-hour TWA ppm)	75% Benzene mg/m^3 (8-hour TWA ppm)
Liquid Wrench 3% Benzene	1.5	1.3	1.7
Liquid Wrench 5% Benzene	2.5	2.17	3.02
Liquid Wrench 7% Benzene	3.5	3.2	3.8

mg/m^3 milligrams per cubic meter
TWA time-weighted average
ppm parts per million

Safety-Kleen for Washing Parts

Mr. Rhyne used a Safety-Kleen parts washer in his high school auto maintenance class, at Setzer's, and at Duke Power. He recalled that gloves were always available at these parts washers. At Setzer's, he recalled spending two, two and a half hours daily cleaning parts.

When he worked in the pipe fab shop at Duke Power, he recalled that he spent at least a half a day working on cutting pipe or either beveling couplings. The other half of the day he was washing parts at the Safety-Kleen parts washer and doing some bending of pipe. His contact with mineral spirits in his use of the typical parts washer involved using a metal sink or tub atop a 30-gallon drum. This apparatus included a spigot, hose and brush, and lamp. Parts were manually washed in the sink with the solvent draining into the reservoir below.

The approved chemicals list for the McGuire Nuclear Power Station includes a Safety-Kleen parts washer solvent.[229]

The benzene content of the materials known as Varsol, petroleum distillate mixtures (mineral spirits, Stoddard Solvent, VM&P naphtha, and other petroleum-derived solvents) has been extensively investigated. Some have reported ranges in benzene content from 1,000 to 10,000 ppm, while others have maintained that levels have been below 100 ppm since the late 1970s. In one analysis conducted on a sample of mineral spirits and reported to Safety-Kleen in December 1980, laboratory results reported that the benzene content was 0.027 milligrams per milliliter (mg/ml) – using a typical density of 825 grams per liter (g/L) for the liquid degreaser, this is converted to 32.7 milligrams per kilograms (mg/kg) or 32.7 ppm by mass for the benzene content

[229] Documents Produced, Cleaner Safety Clean 105 Parts Washing Solvent Red Y 001634 Safety-Kleen Corp.

of this sample analyzed in 1980.[230] Other sources summarized by Kopstein (2011) maintain that until at least 2000, the benzene content of regular mineral spirits has ranged from 1,000 up to 10,000 ppm.[231] In this case there is no indication that the mineral spirits Mr. Rhyne used was formulated in accordance with Rule 66, which applied to California, not North Carolina where he was employed.

The ubiquity of benzene in petroleum-derived products was the subject of testimony to OSHA by Calibourne D. Smith, who was Environmental and Training Manager for the Du Pont Company.[232] Mr. Smith stated that there are no benzene-free substitutes for solvents, and he mentioned that hexane, petroleum-naptha, low flash VM&P and toluene characteristically may contain larger amounts of benzene as impurities than the 0.1% (1,000 ppm). He recounted that some of DuPont's suppliers could meet this level while other suppliers could only assure that the benzene level was between 0.1 to 0.5% (1,000 to 5,000 ppm) in these four solvents. The Agency for Toxic Substances and Disease Registry (ATSDR) stated that Stoddard Solvent (mineral spirits) contained less than 1% benzene, while Hunting et al. (1995) described Varsol as containing 1% benzene.[233] A 1987 material safety data sheet from Texaco for mineral spirits reported that it contained 0.01 to 0.09% benzene.

A 1980 study by the Southwest Research Institute measured benzene concentrations at several distances from open containers of Varsol concluded that at ambient temperatures of about 50 degrees Fahrenheit (°F) and low wind velocities, the highest 8-hour air concentration in the vicinity of the container was 0.02 ppm.[234] At higher temperatures (about 100 °F), however, benzene concentrations ranged from 2.7 to 5.3 ppm at a distance of 6 inches downwind from the container. At a distance of 3 feet and greater, levels were less than 0.2 ppm, and the investigators concluded that 1 ppm benzene was present at a distance of about 1.5 feet from the container.

Another factor in the emissions of benzene from parts washer is the depletion of the benzene content of mineral spirits over time. Williams et al. (2008) in the supplementary data table S4 estimated that the mass of benzene remaining in a parts washer reduced by about two-thirds over a 5-day period in which it was used 8 hours each day.[235] Williams et al. (2008) simulation started

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[230] Documents Produced, SAL SK 7306-7367.

[231] Kopstein M. 2011. Estimating airborne benzene exposures from air monitoring data for mineral spirits. *Journal of Occupational and Environmental Hygiene*, 8(5):300-309.

[232] Testimony of Calibourne D. Smith, comments for the record of OSHA's rulemaking on the benzene standard exemption level.

[233] Hunting KL, Longbottom H, Kalavar SS, Stern F, Schwartz E, and Welch LS. 1995. Haematopoietic cancer mortality among vehicle mechanics. *Occupational and Environmental Medicine*, 52(10):673-678.

[234] Southwest Research Institute, April 1980. Field Study to Determine Emissions of Benzene from "Varsol" Final Report, Project 01-5840-015, Prepared for Exxon by Saenz O, Jr., Taylor M and Skinner J; XOM Emery 200613-200633.

[235] Williams PRD, Panko JM, Unice K, Brown JL, and Paustenbach DJ. 2008. Occupational exposures associated with petroleum-derived products containing trace levels of benzene. *Journal of Occupational and Environmental Hygiene*, 5(9):565-574.

with a parts washer containing mineral spirits at 0.0058% benzene (58 ppm), which equates to 5,334 mg benzene in the parts washer. After 5 days use the benzene content was calculated to be 1,703 mg.

The ART exposure modeling approach has been applied to parts washing with mineral spirits, and the resulting benzene exposure estimates have been compared to several other sources of measured, and estimated benzene exposures.[236] In the LeBlanc et al. (2018) investigation, the ART 50th percentile TWA exposure estimates were closer to the measured exposure values than the other modeling approaches. The ART modeling approach was therefore considered to be suitable to estimate Mr. Rhyne's benzene exposures while using mineral spirits.

In modeling Mr. Rhyne's benzene exposure from use of the parts washer, I conservatively used the same value of 58 ppm benzene from the LeBlanc et al. paper, which is the same value reported by Fedoruk et al. (2003) discussed below.[237] On days when he used a parts washer for a period of 1 hour, his predicted 50th percentile exposure for the 1-hour period was 7.1 mg/m³, with an interquartile confidence interval of 3.7 mg/m³ to 14 mg/m³ (median 2.2 ppm, range 1.2 to 4.4 ppm). The reports of the ART models including input and output values from the models are included in the Appendix. These results are in good agreement with published investigations and summaries of benzene exposures from mineral spirits parts washing. A study published by Fedoruk et al. 2003 measured the emissions and resulting exposures to benzene from a parts washing machine using mineral spirits as the solvent.[238] The solvent used was a recycled degreaser solvent that contained either 9 ppm or 58 ppm benzene. An experimental protocol was followed that was described as simulating aggressive parts washing, including soaking, spray rinsing, brushing, compressed air spraying and inspecting metal parts cleaned in the parts washer. Sixty-minute duration air samples intended to represent the upper bound of exposures to someone using the degreaser showed a personal exposure in the operator's breathing zone of less than 33 parts per billion (ppb) for the 9 ppm benzene content solvent. An area sample taken at breathing zone height over the degreaser showed an airborne benzene concentration of 33 ppb (0.033 ppm) for a 60-minute sample. When the 58 ppm benzene content solvent was used, the personal exposure was measured at 440 ppb benzene while the corresponding breathing zone height area sample was 550 ppb (0.55 ppm) benzene. It should be noted that while I used the same value for benzene content of used mineral spirits as did Fedoruk et al. (58 ppm), I modeled Mr. Rhyne's exposures at a room temperature of 25 °Celsius (77 °F), which I consider to be more representative of his working conditions in North Carolina than the indoor air temperatures of 65 to 68 °F reported by Fedoruk et al. As Fedoruk et al. stated "One can reasonably expect the vapor

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[236] LeBlanc M, Allen JG, Herrick RF, Stewart JH. 2018. Comparison of the near field/far field model and the advanced reach tool (ART) model V1.5: exposure estimates to benzene during parts washing with mineral spirits. *International Journal of Hygiene and Environmental Health*, 221(2):231-238.

[237] Fedoruk M, Bronstein R, and Kerger B. 2003. Benzene Exposure Assessment for Use of a Mineral Spirits-based Degreaser. *Applied Occupational and Environmental Hygiene,* 18(10):764–781.

[238] Fedoruk et al., 2003, previously cited.

emission rates and associated exposure concentrations to approximately double for every 10 °C (18 °F) increase in temperature."[239] Considering this temperature difference, the agreement between Fedoruk et al. values and the exposure estimated for Mr. Rhyne is very good.

Williams et al. in 2008 reviewed a series of studies of vehicle mechanics including the use of mechanical parts washers in a variety of service facilities.[240] The mean of 16 short-term (one minute) airborne benzene samples was 0.45 ppm on initial sampling, and 0.27 ppm on follow-up sampling. Mr. Rhyne used mineral spirits parts washers in his high school (1979-80) classes, his work at Setzer's Automotive, and at Duke Power. On days when he used the parts cleaner for a 15-minute period, his predicted benzene exposure for that 15-minute period was 5.2 mg/m³, with an interquartile confidence interval of 2.7 mg/m³ to 10.0 mg/m³ (median 1.6 ppm, range 0.8 to 3.1 ppm). On days when he used a parts washer for a period of 1 hour, his predicted 50th percentile exposure for the 1-hour period was 7.1 mg/m³, with an interquartile confidence interval of 3.7 mg/m³ to 14 mg/m³ (median 2.2 ppm, range 1.2 to 4.4 ppm). When he used the parts washer for a 2-hour period, his predicted 50th percentile exposure for the 2-hour period was 7.1 mg/m³, with an interquartile confidence interval of 3.7 mg/m³ to 14 mg/m³ (median 2.2 ppm, range 1.2 to 4.4 ppm). When he used the parts washer for a 3-hour period, his predicted 50th percentile exposure for the 3-hour period was 7.1 mg/m³, with an interquartile confidence interval of 3.7 mg/m³ to 14 mg/m³ (median 2.2 ppm, range 1.1 to 4.4 ppm). The reports of the ART models including input and output values from the models are included in the Appendix.

Varsol for Parts Cleaning

Mr. Rhyne described using Varsol in open pails for cleaning parts during his time on the pipefitting crew. Exxon Varsol #18 appears on the McGuire Nuclear Station approved chemicals list.[241] He recalled that he got Varsol by the bucket from the painters, and he used it to clean parts such as bolting and fasteners. He would put the Varsol into an open pail, then soak the parts in the Varsol for 30 minutes or so, then he removed them by reaching down into the pail while wearing leather gloves. He got fresh Varsol twice a week.[242] He used Varsol in the open pail to clean parts as a matter of convenience, at other times he used a parts washer, for example in the turbine building. He also stated that over time, he went to other products for cleaning such as a CRC product, as he started working more on pipe supports.

The ART exposure modeling approach (described above) can be applied to parts washing with mineral spirits in an open pail. Mr. Rhyne recalled that he soaked parts in the pail for 30 minutes then he dipped his hand into the pail wearing a leather glove to remove the part from the solvent. He then cleaned the parts with a brush.

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[239] Fedoruk et al., 2003, previously cited.
[240] Williams et al., 2008, previously cited.
[241] Documents Produced.
[242] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 547.

As previously discussed, the benzene content of Varsol and other petroleum-derived solvents has been extensively investigated. Some have reported ranges in benzene content from 1,000 to 10,000 ppm, while others have maintained that levels have been below 100 ppm since the late 1970s. Considering the disparate reports of the benzene content of fresh (clean, virgin) mineral spirits, in predicting Mr. Rhyne's exposures while using the fresh mineral spirits in the open pail, I did the calculations using three concentrations of benzene: low at 50 ppm, medium at 500 ppm, and high at 1,000 ppm. If he spent 1 hour each day soaking then brushing the parts with the Varsol, on the days when he used fresh mineral spirits, the 1-hour average benzene exposure when he worked with the medium (500 ppm) benzene content fresh mineral spirits was predicted to be 50th percentile (median) of 19 mg/m^3, interquartile confidence interval is 9.7 mg/m^3 to 37 mg/m^3 (6 ppm, range 3.0 – 11.6 ppm). For the low benzene content, his 50th percentile value is 5.8 mg/m^3, range 3 – 11 mg/m^3 (1.8 ppm, 0.9 – 3.4 ppm). For the high benzene content mineral spirits, the 50th percentile value is 34 mg/m^3, range 17 – 66 mg/m^3 (10.6 ppm, range 5.3 to 20.6 ppm).

The benzene content of fresh mineral spirits decays as the solvent is used for cleaning and the benzene vaporizes. Nicas et al. (2006) reported that in a simulation study of parts washing with mineral spirits, the benzene content of the solvent decreased at an exponential rate such that about 50% remained after 5 hours of use.[243] Assuming he used the same bucket of Varsol a second day, using that rate of benzene loss as an approximation for Mr. Rhyne's use of Varsol in the parts cleaning with the open pail, the solvent in the pail on a second day of cleaning would contain about 50% the original benzene content. His benzene exposure would be reduced by half when he used the lower benzene content (the day old) Varsol so his exposure for the 1-hour period of soaking and cleaning would be 3 ppm (range 1.5 to 5.8 ppm) if the fresh Varsol contained 500 ppm benzene; 0.9 ppm (range 0.45 to 1.7 ppm) for the low (100 ppm) benzene Varsol; and 5.3 ppm (range 2.6 to 10.3 ppm) for the high benzene content Varsol.

Kroil

Ice condenser work only took place during outages. In the early 1990s, if the outage was 60 days, 40 days would be spent unloading condenser ice baskets; if the outage was 20 to 30 days, 20 to 24 days would be spent unloading ice baskets. Loading took much less time; he would unload 18 to 20, 48-feet tall ice baskets a day. Each unit had an outage every 18 months. Oconee had 3 units, Catawba 2 units, and McGuire 2 units; while assigned to the Catawba Plant, he would go out with crews to other plants for outages. He was at either Catawba for about 4 months, McGuire for 30 days or Oconee for 30 days.

Mr. Rhyne recalled working with Kroil while at Duke Energy, specifically while working at the Catawba plant from the early 1990s until he became a supervisor in 1998. He used Kroil to break

[243] Nicas M, Plisko MJ, and Spencer JW. 2006. Estimating benzene exposure at a solvent parts washer. *Journal of Occupational and Environmental Hygiene*, 3(5):284-291.

apart ice condenser vibrators, of which there were approximately 70. He would work on them for 40 hours, using Kroil for the entire 10-hour day.

As of 2005, a material safety data sheet (MSDS) from Kroil reported its composition as Severely Hydrotreated Petroleum Distillates, 30-50% (CAS 64742-52-5); Light Petroleum Distillates, 30-50% (CAS 64742-95-6/64742-88-7/64742-47-8); Aliphatic Alcohols 1-5%, Glycol Ether 111-76-2, 1-5%; Proprietary Ingredients, 5-15% (CAS 78-92-2/123-42-2). In a summary table by the 2008 Williams Study, the historical benzene content of petroleum distillate products known as VM&P naphtha, Stoddard Solvent, and Mineral Spirits was reported to range from 0.01 to 0.2% (100 to 2000 ppm) over the time period 1975 to 2002.[244] One hour personal exposures from the use of mineral spirits ranged from <0.006 to 0.44 ppm benzene. In the time period when Mr. Rhyne used this product (1990-1998), the benzene content of petroleum derived solvents reportedly ranged from 100 to 2,000 ppm. I determined the range of Mr. Rhyne's benzene exposures to be 0.01 to 1 ppm with a midrange value of 0.5 ppm for the duration of each use of Kroil.

Marvel Mystery Oil

Mr. Rhyne used Mystery oil during the outages at Catawba when he conducted maintenance work on the ice baskets. The Mystery Oil was used as a lubricant for the vibrator to keep them from freezing up. He worked as a maintenance mechanic from 1986 until he became a supervisor in 1998. They would use ten ounces per oiler, each vibrator had an oiler, and they had 16 vibrators running at each time. They would unscrew the top of the oiler and use a funnel to pour in the Marvel Mystery Oil. The capacity of each oiler was 10 ounces.

As of 1985, Marvel Mystery Oil was reported to contain mineral spirits (30%); and napthenic base oil distillate (67%). A 1995 MSDS disclosed mineral oil, petroleum distillate solvent refined mild, heavy naphthenic (IARC Carcinogen) petroleum luboil (<75%); mineral oil petroleum distillate solvent dewaxed severe, heavy naphthenic /petroleum lubrication oil < 75%; Stoddard Solvent /mineral spirits <30%. Later safety data sheets (1998, 2000, 2001) report petroleum lubricating oil (CAS 64741-96-4) <75%; mineral spirits (CAS 8052-41-3) <30%, and chlorinated hydrocarbons (CAS 61788-76-9) <0.2%. In the time period when Mr. Rhyne used this product at Catawba (1986-1998), the benzene content of petroleum derived solvents reportedly ranged from 100 to 2,000 ppm. As is the case for other such products, I determined that the range of Rhyne's benzene exposures to be 0.01 to 1 ppm with a midrange value of 0.5 ppm for the duration of each use of the Marvel Mystery Oil.

[244] Williams et al., 2008, previously cited.

CRC

The McGuire Nuclear Station approved chemicals list includes a cleaner listed as CRC 3-36 Bulk 000446 CRC Chemicals.[245] Mr. Rhyne recalled using a CRC aerosol product that he got from the toolroom to clean nuts of various sizes as well as bolts and other parts. He cleaned a nut, one nut at a time with CRC. He decided whether he would use a parts washer or the CRC based upon convenience (sometimes he needed to go 80 yards to get to the parts washer), and the size of the components he needed to clean. He stated for example "but if we had a component that was two-foot-long and had eight bolts, we might just use CRC to clean them."[246] He also reported " ...you might have to travel a good 80 yards to get to the parts washer, where CRC you go to the toolroom and get some CRC and clean it on the spot."[247]

As of 2008, the MSDS for CRC Product 3-36® Multi-Purpose Lubricant and Corrosion Inhibitor (aerosol) identified its composition to be Hydrotreated light distillates 65-75% (CAS 64742-47-8); Solvent-refined heavy paraffinic distillates, 15-25% (CAS 64741-88-4); Inhibitor blend proprietary 5-15%, and Carbon dioxide 1-5% (CAS 124-38-9). Hydrotreated distillates have been processed to reduce benzene to cyclohexane. The residual benzene content is variously reported to be in the low ppm range or less than 0.1%.[248] Mr. Rhyne recalled that jobs completed inside the Radiation Control Area (RCA) typically took 2 to 3 hours; preventive maintenance done outside the RCA, turbine, auxiliary, and reactor buildings typically took between 4 and 8 hours. Estimating conservatively that he used the CRC spray for parts cleaning for 1 hour per day, if the CRC product contained 100 ppm benzene, the predicted 50th percentile exposure is 5.9 mg/m^3; interquartile confidence interval 3 mg/m^3 to 11 mg/m^3 (1.85 ppm, 0.94 – 3.45ppm) for the 1 hour he used the cleaner. If the benzene content was 10 ppm, the predicted 50th percentile 1-hour exposure was 0.18 ppm, range of 0.09 – 0.34ppm.

Rapid Tap and Tap Magic

The approved chemicals list for the McGuire Nuclear Power Station includes Pro Tap Magic Cutting Fluid Red Y 002049 Steco Corp. Several MSDSs for Tap Magic products report composition of Distillates (petroleum), hydrotreated light ranging from 40 to 75%. As the record in the case doesn't indicate which of these products Mr. Rhyne used, I have not estimated his benzene exposure from this source.

Spotcheck

In the 1979/1980 to 1983 time period during his work as a Pipefitter, Mr. Rhyne worked in the plant, using Spotcheck to clean the piping after welding. The list of approved chemicals for the McGuire Nuclear Station includes Spotcheck SKC-S Bulk Red 001802 Magnaflux Corporation.

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[245] Documents Produced.
[246] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 431.
[247] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 435.
[248] WHO. 1996. Environmental Health Criteria 187, White Spirit (Stoddard Solvent), pp. 28–41. Geneva: World Health Organization.

The record in this case does not indicate the composition of Spot Check as used by Mr. Rhyne, and I have not estimated his benzene exposure from this source.

Radiation

Mr. Rhyne wore a dosimeter for radiation exposure for times working during active operation (or plants in outage). He recalled being badged for radiation exposure at the Oconee plant, December 1986 to February 1987 where he worked on heat exchangers and steam generators during an outage. Mr. Rhyne's Cumulative Occupational Dose History as recorded on his NRC (U.S. Nuclear Regulatory Commission) Form 4 shows a TEDE (total effective dose equivalent) and TOED (total organ dose equivalent) of 0.650 for the monitoring period 01/07/1987 – 04/30/1987. This was the highest dose recorded in his monitoring history, the second highest was 0.560 for the period 08/29/1985 – 10/31/1985.[249] The NRC Annual Limits are 5 rem (roentgen equivalent man) for the TEDE and 50 rem for the TOED.

EXPOSURE ASSESSMENT BY FACILITY

Home Use

From age 14 through high school (1975) he worked with his dad on cars about 1 day/month for 6 to 7 hrs/day until he began working at Duke. He used Kutzit and Liquid Wrench. He later worked on his own car, he recalled doing this until he left the pipe shop at Duke Power in 1980.

Kutzit

Mr. Rhyne used Kutzit at home working on family cars, which he did about once a month for 6-7 hours each time. Mr. Rhyne recalled using Kutzit while working on cars with his father around ages 14-15; that would have been in 1970. He would use a brush to apply the Kutzit on the gasket, which would take 30 minutes to apply on both gaskets of the valve covers. He would then scrape the valve cover gaskets or oil pan gaskets with a putty knife. Scraping the gaskets took over an hour. He was about 14 so that was in about 1970 when he started this work on cars, until he started at Duke in 1976. He didn't use Kutzit every time. The work on family cars was done outside, and he did not wear gloves.

I conservatively estimated that Mr. Rhyne used Kutzit one-third of the times he worked on the family cars. The results of the ART model for using Kutzit containing 50% benzene outdoors for a 90-minute period are 62 mg/m^3 median, interquartile confidence interval is 47 mg/m^3 to 84 mg/m^3; this is 19.5 ppm (range 14.8 – 26.4 ppm) for a 90-minute period. The daily average for an 8 hour period is [(19.5 ppm) (90 min) + (0) (390 min)]/480 min = 3.66 (range 2.78 – 4.95 ppm). If he used Kutzit one day in 3 when he worked on cars, and he worked on cars one day per month, his daily average exposure over each year was 0.04 ppm (range 0.03 – 0.06 ppm).

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[249] Documents Produced, Exhibit 3 Rhyne.

Liquid Wrench

Mr. Rhyne worked on his father's and his own cars at home which involved pulling transmission, replacing transmissions, working on motor and valve covers among other tasks; he recalled using Liquid Wrench for his home auto work. He stopped working on his father's cars in about 1978. Mr. Rhyne estimated working on his car two days a week mostly in the summer months. He estimated using half a can of the Liquid Wrench over the weekend working on his car. Until the time he left the pipe fab shop at Duke Energy in 1980 he still worked on his cars to some extent.

Based upon the record in this case, it appears that the working conditions under which Mr. Rhyne used Liquid Wrench in work on vehicles at home most closely resembled scenario 10 which was work done outside. The only data for use of Liquid Wrench outdoors is scenario 10 from Williams, using Liquid Wrench with 14% benzene, the 15-minute average exposure was 0.92 ppm; the 1-hour personal exposure was 0.46 ppm. If Mr. Rhyne's work on cars was two days a week for 6 months a year, for one hour each time, his average daily exposure over a year was [(0.46 ppm) (1 hour) + (0) (7 hours)] / 8 hours = 0.06 ppm. Adjusting for 2 of 5 days per week (40%) and 6 of 12 months of the year (50%), his daily average benzene exposure from this source is 0.01 ppm.

East Lincoln High School

During high school, he was in shop class his Junior and Senior years (1974, 1975) for 2 to 3 hours/day in the afternoon, except the one day he would go to the car dealership (Setzer's). He was there 1x/week for 3 to 4 hours/day. In class he used Liquid Wrench, Safety-Kleen Parts Washer, and Kutzit; he only used gloves with Parts Washer. He recalled never wearing a respirator or gloves when using Kutzit. Shop was a separate building, about 50 feet wide x 40 feet in depth with a 10 feet high ceiling; it had a rollup door and he did not recall any fans.

Kutzit

Mr. Rhyne thought that he had used Kutzit in his high school class but no details on that use were provided.

Liquid Wrench

In school, the work appears to have been conducted in a facility with medium ventilation (garage doors that were opened), as was the case for scenarios 1 through 5 in the Williams 2008 study. The average of the 15-minute benzene exposures in these scenarios was 1.24 ppm (range 0.08 to 3.79 ppm). The average 1 hour personal exposure was 0.76 ppm (range 0.04 – 2.61 ppm). This would result in an average daily exposure of 0.10 ppm (range 0.005 – 0.33 ppm) from Liquid Wrench. Adjusting for a 9 month school year, daily average is 0.075 ppm (range 0.004 – 0.25 ppm).

Safety-Kleen Parts Washer

Mr. Rhyne reported using a Safety-Kleen parts washer to clean parts using a brush including carburetors, bolting on valve covers and bolting on transmissions. He estimated spending an hour to an hour and a half using Liquid Wrench at the mechanic shop in school at least 4 days a week. The class was 4 days a week for 2-3 hours each time. I estimate that he used the parts washer for 1 hour each class, since he reported using Liquid Wrench for 1 – 1.5 hours each class. On days when he used a parts washer for a period of 1 hour, his predicted 50th percentile exposure for the 1-hour period was 7.1 mg/m^3, with an interquartile confidence interval of 3.7 mg/m^3 to 14 mg/m^3 (median 2.2 ppm, range 1.2 to 4.4 ppm). This would result in a daily average of 0.28 ppm (range 0.15 – 0.55 ppm) from this source. Adjusting for a 9-month school year, daily average is 0.21 ppm (range 0.11 – 0.41 ppm).

Setzer's

During the school year, Mr. Rhyne recalled working at Setzer's about 3 or 4 hours, one day per week. The majority of that time was cleaning gaskets and parts using the parts washer. So in a four hour day, 2.5 to three hours of that would have been either working on gaskets or cleaning parts. Some days when he went to Setzer's he might have a full day of gaskets. The next week he cleaned bolting or carburetors or the like. When he removed gaskets at Setzer's, he used Kutzit for about an hour, and wore gloves while using it.

Liquid Wrench

The shop had 4 rollup doors, lifts, bays, and was 60 feet wide x 100 feet deep and with 14 feet high ceilings. The doors were open only during warm weather. I estimate that he would spend an average of four hours per week on these vehicle maintenance activities. Since Liquid Wrench would be used to loosen parts such as spark plugs, wheel nuts, etc., a reasonable pattern of use would have been a once per hour, resulting in 4 of the 15 minute intervals of Liquid Wrench use per week. The work appears to have been conducted in facilities with medium ventilation (garage doors that were opened), as was the case for scenarios 1 through 5 in the Williams 2008 study. The average of the 15-minute benzene exposures in these scenarios was 1.24 ppm (range 0.08 to 3.79 ppm). The average 1 hour personal exposure was 0.76 ppm (range 0.04 – 2.61 ppm). Therefore, if he used Liquid Wrench four times, each time for a 15-minute work cycle, total of 60 minutes exposure, his daily average benzene exposure would be 1.24 ppm x 60 min/480 min = 0.16 ppm benzene. Adjusting for his time at Setzer's (1 day each week) and a 9 month school year, the average daily benzene exposure was 0.02 ppm (range 0.001 – 0.071 ppm).

Kutzit

At Setzers, Mr. Rhyne recalled using Kutzit to remove gaskets, he did not use it every time he worked at Setzer's. He reported that he used gloves during this use at Setzer's but he did not specify the type or material of these gloves. When he worked removing gaskets, he recalled using Kutzit for periods of about an hour per day. Since he worked at Setzer's during his junior and

senior years (1974 and 1975), it is reasonable, therefore to assume that Mr. Rhyne used Kutzit with benzene as an ingredient through 1974, and that the Kutzit formula he used starting in 1975 contained 25 to 50% toluene by weight.

The benzene containing paint stripper measured at 52% benzene by Young (1978) generated 5 minute air benzene levels ranging from 73 to 225 ppm (average 130 ppm over a 25-minute period).[250] So for the years before 1975, I used the value of 130 ppm for the benzene exposure when Mr. Rhyne used Kutzit for a 1-hour period, which includes a 30-minute period of scraping off the old gasket that had been treated with Kutzit. If he used Kutzit 1 hour per day, 1 day per week, for a school year of 9 months duration, his daily average exposure was [130 ppm (1 hour) + (0 ppm) (7 hours)] /8 hours = 16.25 ppm. Since he did this 1 day per week (20%) of the days and 9 months of the year (75%), his daily average exposure was 2.44 ppm for his junior year (1974). As he recalled that some days when he went to Setzer's he might have a full day of gaskets; the next week he cleaned bolting or carburetors, I estimated his average daily exposure from removing gaskets to be 2.44/2 = 1.22 ppm.

The Kutzit Mr. Rhyne used at Setzer's in 1975 contained 25 to 50% toluene which was 0.1 to 1% benzene (so the Kutzit was 0.025 to 0.5% benzene). Proportionately then the average benzene air levels from the use of the toluene-containing Kutzit are calculated to average 0.65 ppm, range 0.06 to 1.25 ppm for the 25-minute period. I used the value of 0.65 ppm for the benzene exposure when Mr. Rhyne used Kutzit for a 1-hour period, which includes a 30 minute period of scraping off the old gasket that had been treated with Kutzit. If he used Kutzit 1 hour per day, 1 day per week, for a school year of 9 months duration, his daily average exposure was [0.65 ppm (1 hour) + (0 ppm) (7 hours)] /8 hours = 0.08 ppm. Since he did this 1 day per week (20%) and 9 months of the year (75%), his daily average exposure was 0.01 ppm for his senior year (1975). Adjusting for working on gaskets half the days he was at Setzer's, his average daily exposure was 0.005 ppm.

Parts Washer

Mr. Rhyne recalled using the Safety-Kleen parts washer at Setzer's for 2 to 2.5 hours each day. When he used the parts washer for a 2 hour period, his predicted 50th percentile exposure for the 2-hour period was 7.1 mg/m^3, with an interquartile confidence interval of 3.7 mg/m^3 to 14 mg/m^3 (median 2.2 ppm, range 1.2 to 4.4 ppm). If he used the parts washer 1 day per week, for a school year of 9 months duration, his daily average exposure was [2.2 ppm (2 hour) + (0 ppm) (6 hours)] /8 hours = 0.55 ppm. Since he did this 1 day per week (80%) and 9 months of the year (75%), his daily average exposure was 0.1 ppm for his senior year (1975). Adjusting for using the parts washer half the days he was at Setzer's his average daily exposure was 0.05 ppm.

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[250] Young RJ, Rinsky RA, and Infante PF. 1978. Benzene in Consumer Products. *Science,* 199:248-248.

Duke Energy

Mr. Rhyne was employed at Duke Energy Corporation (Duke) from April 26, 1976 (age 19) until May 2015, total approximately 39.5 years. His first position was from April 1976 to July 1976 (3 months) as a Railroad Technician. He constructed a spur for railroad on the Duke property. Other than creosote, he reported no chemical exposures while working at this job.

His second position from July 1976 to 1980 was at the McGuire Nuclear Station, Huntersville, NC in the Pipe Fabrication Shop where he was a Pipefitter. He recalled using Liquid Wrench, a Safety-Kleen parts washer, and Spotcheck in the Pipe Fab shop.

Liquid Wrench

Mr. Rhyne beveled, bent and cut pipe using Liquid Wrench as a lubricant during this job. He recalled using liquid wrench "a bunch because we sawed and sawed and sawed piping". He stated that he probably might wind up using six cans a week (on average), each can was 16 oz.[251] For this rate of use of Liquid Wrench, I calculated his daily benzene exposure to be 1.52 ppm, range 1.3 – 1.7 ppm for Liquid Wrench containing 3% benzene. For Liquid Wrench containing 5% benzene, his daily average exposure was 2.50 ppm, range 2.17 – 3.02; for 7% benzene it was 3.5 ppm, range 3.2 – 3.8 ppm.

Safety-Kleen Parts Washer

Mr. Rhyne reported that out of the 8 hour per day/40-hour week, he spent 50% of his time cleaning parts in the Safety-Kleen parts washer in the fab shop. He wore rubber gloves while using the Safety-Kleen parts washer. When he used the parts washer for a 3-hour period, his predicted 50th percentile exposure for the 3-hour period was 7.1 mg/m^3, with an interquartile confidence interval of 3.7 mg/m^3 to 14 mg/m^3 (median 2.2 ppm, range 1.1 to 4.4 ppm). His daily average 8-hour TWA exposure was 0.82 ppm (range 0.41 – 1.65 ppm).

Spotcheck

Mr. Rhyne recalled sometimes using a product called Spot Check to clean some of the piping and reported, "but it was very little".

His third position was as a Pipefitter in the plant from 1979/1980 to 1983. In this position he used Kutzit, Rapid Tap, Varsol, and Spotcheck. He recalled that he hardly used Liquid Wrench in the plant

Kutzit

Mr. Rhyne remembered using Kutzit in the maintenance timeframe of his employment at Duke, starting in 1985. From 1985-98 he used Kutzit for removing gaskets from flanges. He estimated

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[251] Deposition of Bruce C. Rhyne, July 13, 2017 – August 17, 2018, Page 265.

that in a month's time he used Kutzit on Garlock gaskets about 30% of the time. He used a brush to apply the Kutzit, and depending on the size of the gaskets, he used Kutzit for probably an hour of the 3-hour period he worked on each gasket. He reported that he normally wore gloves but did not specify the material or type of glove. There was a time or two when didn't have gloves on, and he got Kutzit on the back of his hands or on his arm above the wrist.

The Kutzit Mr. Rhyne used in 1985 and later contained 25 to 50% toluene which was 0.1 to 1% benzene (so the Kutzit was 0.025 to 0.5% benzene). Proportionately then the average benzene air levels from the use of the toluene-containing Kutzit are calculated to average 0.65 ppm, range 0.06 to 1.25 ppm for the 25-minute period. Using this benzene exposure for the 1-hour period he used Kutzit in his 8-hour day, the daily average was 0.08 ppm (range 0.008 – 0.16). Adjusting for his reported use of Kutzit 30% of the time, the resulting daily average exposure is 0.024 (range 0.002 – 0.048 ppm).

Rapid Tap

Mr. Rhyne used Rapid Tap or tap magic as a lubricant for metal while drilling holes in metal ice plates that were used for pipe supports. He recalled using it about 20% of the time in a given week. Information on the composition of these products states that some contain hydrotreated petroleum distillates; others do not appear to contain petroleum distillates. I have not estimated his benzene exposure from this source

Varsol

Mr. Rhyne recalled using Varsol on the pipefitting crew to clean items such as bolting and fasteners. He recalled going to the painters at Duke to get the Varsol; they would pump it out of their barrel into an open pail that he would carry back to his work station. He reported that in a weeks' time, he would probably go twice a week to the painters to get another pail of Varsol when it got dirty. They would place the fasteners/bolts into the pail to clean them. He would soak the items for about 30 minutes before brushing. If he spent 1 hour each day soaking then brushing the parts with the Varsol, on the days when he used fresh mineral spirits, the 1-hour average benzene exposure when he worked with the medium (500 ppm) benzene content, was predicted to be 50th percentile (median) of 19 mg/m^3, interquartile confidence interval is 9.7 mg/m^3 to 37 mg/m^3 (6 ppm, range 3.0 – 11.6 ppm). For the low benzene content, his 50^{th} percentile value is 5.8 mg/m^3, range 3 – 11 mg/m^3 (1.8 ppm, range 0.9 – 3.4 ppm). For the high benzene content mineral spirits, the 50^{th} percentile value is 34 mg/m^3, range 17 – 66 mg/m^3 (10.6 ppm, range 5.3 – 20.6 ppm).

The benzene content of fresh mineral spirits decays as the solvent is used for cleaning and the benzene vaporizes. Nicas (2006) reported that in a simulation study of parts washing with mineral spirits, the benzene content of the solvent decreased at an exponential rate such that about 50%

remained after 5 hours of use.[252] Using that rate of benzene loss as an approximation for Mr. Rhyne's use of Varsol in the parts cleaning with the open pail, the solvent in the pail on a second day of cleaning would contain about 50% the original benzene content. His benzene exposure would be reduced by half when he used the lower benzene content (the day-old) Varsol so his exposure for the 1-hour period of soaking and cleaning would be 3 ppm (range 1.5 to 5.8) if the fresh Varsol contained 500 ppm benzene; 0.9 ppm (range 0.45 to 1.7) for the low (100 ppm) benzene content Varsol; and 5.3 ppm (range 2.6 to 10.3) for the high benzene content Varsol. Averaging the days when he used fresh mineral spirits and day-old mineral spirits, for the mineral spirits that was initially containing 500 ppm benzene, the average for the 1-hour exposure would be 4.5 ppm range 2.75 – 8.7 ppm. The daily 8-hour TWA is 0.56 ppm, range 0.34 – 1.09 ppm.

From 1983 to January 2015, Mr. Rhyne was based at the Catawba facility, however he reported that he went back to McGuire and Oconee facilities on several occasions. He was a Pipefitter/Hanger Support Mechanic from 1983 to 1986/1988 at the Catawba Nuclear power plant Installing pipe. In this position he used CRC cleaner, Kroll, and a parts washer.

He would use the Safety-Kleen parts washer and CRC to clean parts—nuts, bolts, washers; all these parts would be less than an inch. He would use the CRC or the Safety-Kleen parts washer depending on convenience; the percentage of nuts and bolts and washer that he cleaned during the period of 1991/1992 to 1998 in a parts washer vs. CRC was 70%.

Safety-Kleen Parts Washer

Mr. Rhyne used a Safety-Kleen parts washer; he recalled there were three each located in the machine shop, the hot shop, and upstairs above the shop. Besides Safety-Kleen, during the 2000 time frame, he recalled Zep was used in the washer. Before 1998 when he became a supervisor, if he had occasion himself to wash a part, he could be at the parts washer all day but reported that parts washing wouldn't be a daily occurrence. I conservatively estimate that that he used the Safety-Kleen parts washer 1 hour per day on average, so his predicted 50th percentile exposure for the 1-hour period was 7.1 mg/m^3, with an interquartile confidence interval of 3.7 mg/m^3 to 14 mg/m^3 (median 2.2 ppm, range 1.2 to 4.4 ppm). His daily average exposure then for the 8-hour TWA, adjusting for the reported use of the parts washer 70% of the time, is 0.2 ppm, range 0.11 – 0.38 ppm.

CRC Cleaners

Mr. Rhyne recalled using CRC about 30% of the time for parts cleaning from 1985 to 1990s "and up to maybe 2000" timeframe. He recalled that it was originally an aerosol, but that Duke switched to pump sprayers. One piece of equipment would have "like 288 nuts, 144 studs, 288 washers" and that some days they would use it all day long. Estimating conservatively that he

[252] Nicas M, Plisko MJ, and Spencer JW. 2006. Estimating benzene exposure at a solvent parts washer. *Journal of Occupational and Environmental Hygiene*, 3(5):284-291.

used the CRC spray for parts cleaning for 1 hour per day, if the CRC product contained 100 ppm benzene, the predicted 50th percentile exposure is 5.9 mg/m³; interquartile confidence interval 3 mg/m³ to 11 mg/m³ (1.85 ppm, range 0.94 – 3.45 ppm) for the 1 hour he used the cleaner. His average exposure for an 8 hour day, considering he used CRC 30% of the time, was 0.07 ppm, range 0.04 – 0.13 ppm. If the benzene content was 10 ppm, the predicted 50th percentile 1-hour exposure was 0.18 ppm, range 0.09 – 0.34 ppm, for an adjusted daily average of 0.007ppm, range 0.003 – 0.013 ppm.

Marvel Mystery Oil

Mr. Rhyne reported using Marvel Mystery Oil when performing maintenance on ice condensers during the early 90s till 1998 timeframe.

Kroil

Mr. Rhyne recalled working with Kroil, specifically while working at the Catawba plant from the early 1990s until he became a supervisor in 1998. He used Kroil to break apart ice condenser vibrators, of which there were approximately 70. He would work on them for 40 hours, using Kroil for the entire ten hour day. In the time period when Mr. Rhyne used this product (1990-1998), the benzene content of petroleum derived solvents reportedly ranged from 100 to 2,000 ppm. As is the case for other such products, I determined the range of Mr. Rhyne's benzene exposures to be 0.01 to 1 ppm with a midrange value of 0.5 ppm for the duration of each use of Kroil. Since he recalled using it over the entire workday, I estimated his daily exposure at 0.5 ppm, range 0.01 – 1 ppm.

Work During Outages

Mr. Rhyne recalled several temporary work assignments during outages. These included part-time work at the Cliffside Steam Plant, NC Steam plant, work at the Catawba Nuclear during an outage, at the Oconee Nuclear Plant, and the SC Nuclear power plant. His recollections of chemical use during these temporary assignments do not support estimation of his cumulative exposures.

Mr. Rhyne became a supervisor in 1998. As a supervisor, he reported that from early 1998 to mid-2000 timeframe, he was more involved with his work and that he would wear gloves to observe and ensure parts were cleaned to pass inspections; he would observe the parts while they were in the parts washer as well as outside of the parts washer. As a supervisor, he reported doing some cleaning but generally did more observations than hands on work. He estimated 20% of the time in a work week for helping on cleaning bolting and observing, which varied from time to time. Mr. Rhyne recalled that at some point in the 2000-timeframe from about 2005 to 2008 when he was a supervisor, Duke went from using Safety-Kleen to Zep parts washers. He recalled that Zep was used in the parts washer that was located in the radiation control area (RCA) in the hot machine shop of the Catawba, McGuire, and Okonee plants in which he supervised during this

timeframe of 2000s. Mr. Rhyne left work in May of 2015, received 6 months of short-term disability and then went on long-term disability.

Table 3 Daily Average Benzene Exposure by Product and Facility

Process/Product	Daily Exposure Midpoint (ppm)	Daily Exposure Range (ppm)
Kutzit		
Home use	0.04	0.03 – 0.06
East Lincoln High School	Not determined	–
Setzer's 1974	1.22	–
Setzer's 1975	0.005	–
Duke Energy – Maintenance	0.024	0.002 – 0.048
Rust Penetrant Liquid Wrench		
Home use	0.01	–
East Lincoln High School	0.075	0.004 – 0.25
Setzer's	0.02	0.001 – 0.07
Duke Energy – Pipe Fab Shop		
LW containing 3% benzene	1.5	1.3 – 1.7
LW containing 5% benzene	2.5	2.17 – 3.02
LW containing 7% benzene	3.5	3.2 – 3.8
Safety-Kleen Mineral Spirits Parts Washers		
East Lincoln High School	0.21	0.11 – 0.41
Setzer's	0.05	–
Duke Energy – Pipe Fab Shop	0.82	0.41 – 1.65
Duke Energy – Maintenance	0.2	0.11 – 0.38
Mineral Spirits Cleaning		
Duke Energy – Maintenance	0.56	0.34 – 1.09
Spotcheck		
Duke Energy	Not determined	–
Tap Magic/Rapid tap		
Duke Energy	Not determined	–
CRC products		
Duke energy – Maintenance [10 ppm benzene]	0.007	0.003 – 0.013
Duke energy – Maintenance [100 ppm benzene]	0.07	0.04 – 0.13
Kroil		
Duke Energy – Maintenance	0.5	0.01 – 1.0
Marvel Mystery Oil		
Duke Energy – Maintenance	Not determined	–

DERMAL EXPOSURES

Mr. Rhyne stated that he had skin contact with some materials he worked with, particularly Liquid Wrench while he was beveling and cutting metal parts. The potential for skin exposure to

benzene is noteworthy, as American Conference of Governmental Industrial Hygienists (ACGIH), National Institute for Occupational Safety and Health (NIOSH) and U.S. Occupational Safety and Health Administration (OSHA) have designated dermal uptake as a significant route of exposure for benzene. NIOSH states that "The "[skin]" designation indicates the potential for dermal absorption; skin exposure should be prevented as necessary through the use of good work practices, gloves, coveralls, goggles, and other appropriate equipment."[253]

CUMULATIVE EXPOSURES

Home Use

From age 14 through high school (1975), Mr. Rhyne worked with his dad on cars about 1 day/month for 6 to 7 hrs/day until he began working at Duke. He used Kutzit and Liquid Wrench. He later worked on his own car, he recalled doing this until he left the pipe shop at Duke Power in 1980.

Kutzit

Mr. Rhyne recalled using Kutzit while working on cars with his father around ages 14-15; that would have been in 1970. His daily average exposure over each year was 0.04 ppm (range 0.03 – 0.06 ppm), so his cumulative benzene exposure from home use of Kutzit was 0.24 ppm-years (range of 0.18 – 0.36 ppm-years). He also used Liquid Wrench at home, working on his and his father's cars. I estimated his daily average benzene exposure from this source is 0.01 ppm, for a cumulative benzene exposure of 0.1 ppm-years.

East Lincoln High School

Mr. Rhyne recalled being in shop class his Junior and Senior years (1974, 1975) for 2 to 3 hours/day in the afternoon, except the one day he would go to the car dealership (Setzers). In class he used Liquid Wrench, Safety-Kleen Parts Washer, and Kutzit. He thought that he had used Kutzit in his high school class but no details on that use were provided.

Liquid Wrench

Mr. Rhyne's daily average benzene exposure was 0.075 ppm (range 0.004 – 0.25 ppm) from this source. His cumulative benzene exposure was 0.15 ppm-years (range 0.08 – 0.5 ppm-years).

Safety-Kleen Parts Washer

Mr. Rhyne's daily average exposure from using the Parts Washer was 0.21 ppm (range 0.11 – 0.41 ppm). His cumulative benzene exposure from this source was 0.42 ppm-years (range 0.22 – 0.82 ppm-years).

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[253] The NIOSH Pocket Guide, http://www.cdc.gov/niosh/npg/pgintrod.html#exposureroute.

Setzer's

Kutzit

Mr. Rhyne used Kutzit in 1974 and 1975 at Setzer's; I estimated his exposures separately for these years to account for the change in benzene concentration in Kutzit over that time. His daily average exposure in 1974 was 1.22 ppm; in 1975 it was 0.005 ppm. His cumulative benzene exposure then was 1.22 ppm-years for 1974, and 0.05 ppm-years for 1975.

Liquid Wrench

Mr. Rhyne's daily average benzene exposure from his work at Setzer's was 0.02 ppm (range 0.001 – 0.071ppm). His cumulative benzene exposure from this source then was 0.048 ppm-years (range 0.002 – 0.142 ppm-years).

Safety-Kleen Parts Washer

Mr. Rhyne recalled using the Safety-Kleen parts washer about half the days he worked at Setzer's. His average daily exposure was 0.05 ppm (range 0.03 – 0.1 ppm). His cumulative benzene exposure from this source was 0.1 ppm-years (range 0.06 – 0.2 ppm-years).

Duke Energy

Kutzit

Mr. Rhyne remembered using Kutzit in the maintenance timeframe of his employment at Duke, starting in 1985. From 1985-1998 he used Kutzit for removing gaskets from flanges. Adjusting for his reported use of Kutzit 30% of the time, the resulting daily average exposure is 0.024 ppm (range 0.002 – 0.048 ppm). His cumulative benzene exposure from this source was 0.31 ppm-years (range 0.03 – 0.62 ppm-years).

Liquid Wrench

Mr. Rhyne used Liquid Wrench in the Pipe Fab Shop where he beveled, bent and cut pipe using Liquid Wrench as a lubricant. I calculated his daily benzene exposure to be 1.52 ppm, range 1.3 – 1.7 ppm for Liquid Wrench containing 3% benzene. For Liquid Wrench containing 5% benzene, his daily average exposure was 2.50 ppm, range 2.17 – 3.02 ppm; for 7% benzene it was 3.5 range 3.2 – 3.8 ppm. The corresponding cumulative benzene exposures from this source are for Liquid Wrench containing 3% benzene: 3.75 ppm-years (range 3.25 – 4.25 ppm-years); for Liquid Wrench containing 5% benzene, 6.25 ppm-years (range 5.42 – 7.55 ppm-years); for Liquid Wrench containing 7% benzene, 8.75 ppm-years (range 8.00 – 9.50 ppm-years).

Safety-Kleen Parts Washer

Mr. Rhyne used a Safety-Kleen parts washer during his maintenance activities, before he became a supervisor in 1998. He recalled that he could be at the parts washer all day but reported that parts washing wouldn't be a daily occurrence. His daily average exposure then for the 8 hour TWA, adjusting for his reported use of the parts washer 70% of the time is 0.2 ppm, range 0.11–

0.38 ppm. The corresponding cumulative benzene exposure is 1.4 ppm-years (range 0.77 – 2.66 ppm-years).

He also used a Safety-Kleen parts washer in the Pipe Fab shop. Mr. Rhyne reported that out of the 8 hour per day/40 hour week, he spent 50% of his time cleaning parts in the Safety-Kleen parts washer in the fab shop. His daily average 8 hour TWA exposure was 0.82 ppm (range 0.41 – 1.65 ppm), corresponding to 2.49 ppm-years (range 1.23 – 4.95 ppm-years).

Varsol (mineral spirits) Cleaning

Mr. Rhyne recalled using Varsol on the pipefitting crew to clean items such as bolting and fasteners. He recalled going to the painters at Duke to get the Varsol. His daily average benzene exposure from this source was 0.56 ppm (range 0.34 – 1.09 ppm). His cumulative benzene exposure was 2.8 ppm-years (range 1.7 – 5.45 ppm-years).

CRC Products

Mr. Rhyne recalled using CRC about 30% of the time for parts cleaning from 1985 to 1990s "and up to maybe 2000" timeframe. If the CRC product contained 100 ppm benzene, the predicted 50th percentile daily exposure is 0.07 ppm, range 0.04 – 0.13 ppm. If the benzene content was 10 ppm, the predicted 50th percentile daily average was 0.007 ppm, range 0.003 – 0.013 ppm. The corresponding cumulative exposures are 0.49 ppm-years (range 0.21 – 0.91 ppm-years) for the 100 ppm benzene cleaners; 0.049 ppm-years (range 0.021 – 0.091 ppm-years) for 10 ppm benzene cleaners.

Kroil

Mr. Rhyne worked with Kroil at the Catawba plant from the early 1990s until he became a supervisor in 1998. He used Kroil to break apart ice condenser vibrators, of which there were approximately 70. He would work on them for 40 hours, using Kroil for the entire ten hour day. I estimated his daily exposure at 0.5 ppm, range 0.01 – 1 ppm. The corresponding cumulative benzene exposures are 3.5 ppm-years (range 0.07 – 7 ppm-years).

Table 4 Cumulative Benzene Exposure by Product and Facility		
Process/Product	Cumulative Exposure Midpoint (ppm-years)	Cumulative Exposure Range (ppm-years)
Kutzit		
Home use	0.24	0.18 – 0.36
East Lincoln High School	Not determined	–
Setzer's 1974	1.22	–
Setzer's 1975	0.05	–
Duke Energy – Maintenance	0.31	0.03 – 0.62
Rust Penetrant Liquid Wrench		
Home use	0.1	–
East Lincoln High School	0.15	0.08 – 0. 5
Setzer's	0.048	0.002 – 0.142
Duke Energy – Pipe Fab Shop		
LW containing 3% benzene	3.75	3.25-4.25
LW containing 5% benzene	6.25	5.42-7.55
LW containing 7% benzene	8.75	8.00-9.50
Safety-Kleen Mineral Spirits Parts Washers		
East Lincoln High School	0.42	0.22 – 0.82
Setzer's	0.1	0.06 – 0.2
Duke Energy – Pipe Fab Shop	2.49	1.23 – 4.95
Duke Energy – Maintenance	1.4	0.77 – 2.66
Mineral Spirits Cleaning		
Duke Energy – Maintenance	2.8	1.7 – 5.45
Spotcheck		
Duke Energy	Not determined	–
Tap Magic/Rapid tap		
Duke Energy	Not determined	–
CRC products		
Duke Energy – Maintenance		
10 ppm benzene	0.049	0.021 – 0.091
100 ppm benzene	0.49	0.21 – 0.91
Kroil		
Duke Energy – Maintenance	3.5	0.07 – 7.0
Marvel Mystery Oil		
Duke Energy – Maintenance	Not determined	–
Total		
Low (3% benzene LW, 10 ppm benzene CRC)	17.07	8.86 – 28.37
Medium (5% benzene LW, 10 ppm benzene CRC)	19.57	13.04 – 33.5
High (7% benzene LW, 100 ppm benzene CRC)	21.63	13.8 – 34.44

CONCLUSIONS

In addition to the opinions expressed in this report, I have come to the following conclusions:

Exposure to benzene from use of Kutzit:
Mr. Rhyne's cumulative benzene exposure was 1.82 ppm-years (range 0.05 – 1.22 ppm-years) from his use of Kutzit.

Exposure to benzene from use of Liquid Wrench rust penetrant:
Mr. Rhyne's cumulative benzene exposure was 6.55 ppm-years (range 0.1 – 6.25 ppm-years) from his use of Liquid Wrench containing 5% benzene.

Exposure to benzene from CRC cleaners:
Mr. Rhyne was exposed to 0.05 ppm-years (range 0.02 – 0.09 ppm-years) benzene for cleaner containing 100 ppm benzene; 0.49 ppm-years (range 0.2 – 0.9 ppm-years) for cleaner containing 10 ppm benzene.

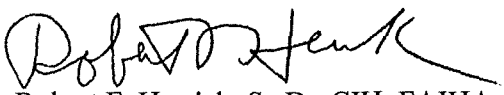
Exposure to benzene from mineral spirits parts washers:
Mr. Rhyne was exposed to 4.41 ppm-years (range 0.1 – 2.49 ppm-years) benzene from this source.

Exposure to benzene from mineral spirits in open buckets:
Mr. Rhyne was exposed to 2.8 ppm-years (range 1.7 – 5.4 ppm-years) benzene from this source.

Exposure to benzene from Kroil:
Mr. Rhyne was exposed to 3.5 ppm-years (range 0.07 – 7.0 ppm-years) benzene from this source.

The total mean cumulative benzene exposures Mr. Rhyne experienced ranged from 8.86 to 34.44 ppm-years with a midpoint estimate of 19.77 ppm-years. This exposure is an underestimate of Mr. Rhyne's total exposure because it does not include significant dermal exposures he experienced, particularly during the use of Liquid Wrench as a lubricant while machining parts.

I hold these opinions and conclusions to a reasonable degree of scientific certainty. If additional information becomes available, I reserve the right to modify, amend, or supplement this report.



Robert F. Herrick, Sc.D., CIH, FAIHA

September 17, 2019

Appendix

APPENDIX

ART REPORT – spreading kutzit for removing gaskets at home – 29-Aug-19

spreading kutzit for removing gaskets

Chemical details

Chemical	benzene
CAS No.	71-43-2

Scenario details

Number of activities	1
Total duration (mins)	90
Nonexposure period (mins)	0

Metadata

ART version	1.5
Creator	
Date created	29-Aug-19
Date last edited	01-Jan-01

Details for Activity spreading Kutzit to remove gaskets

Emission sources:	Near field ✓	Duration (mins):	90
	Far field		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12691 Pa
Liquid mole fraction	0.5
Activity coefficient	2

Activity emission potential

Activity class	Spreading of liquid products
Situation	Spreading of liquids at surfaces or work pieces 0.1 - 0.3 m² / hour

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Outdoors
Source located close to buildings?	No

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 120 mg/m³.

The inter-quartile confidence interval is 53 mg/m³ to 290 mg/m³.

Bayesian model results

Data source	Proj. ref.		No. of sites	No. of workers	No. of records
Spreading of glue [<1.5 hours, no controls]	V6894		4	5	7
		Totals	**4**	**5**	**7**

The predicted 50th percentile long-term exposure is 62 mg/m³.

The inter-quartile confidence interval is 47 mg/m³ to 84 mg/m³.

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IH Mod 2.0

The Two-Zone Model with a Constant Emission Rate

Model # 8a

Simulation type

Iterations: 200

195 sec. *205 calc./sec*

1- Emission rate (mg/min)

G — Normal

Average	Std. Dev.
62.4	5

2-Ventilation rate (m³/min)

Q — Normal

Average	Std. Dev.
200	4

3-Random Air Velocity (m/min)

S — Normal

Average	Std. Dev.
3.7	0.5

Near field shape

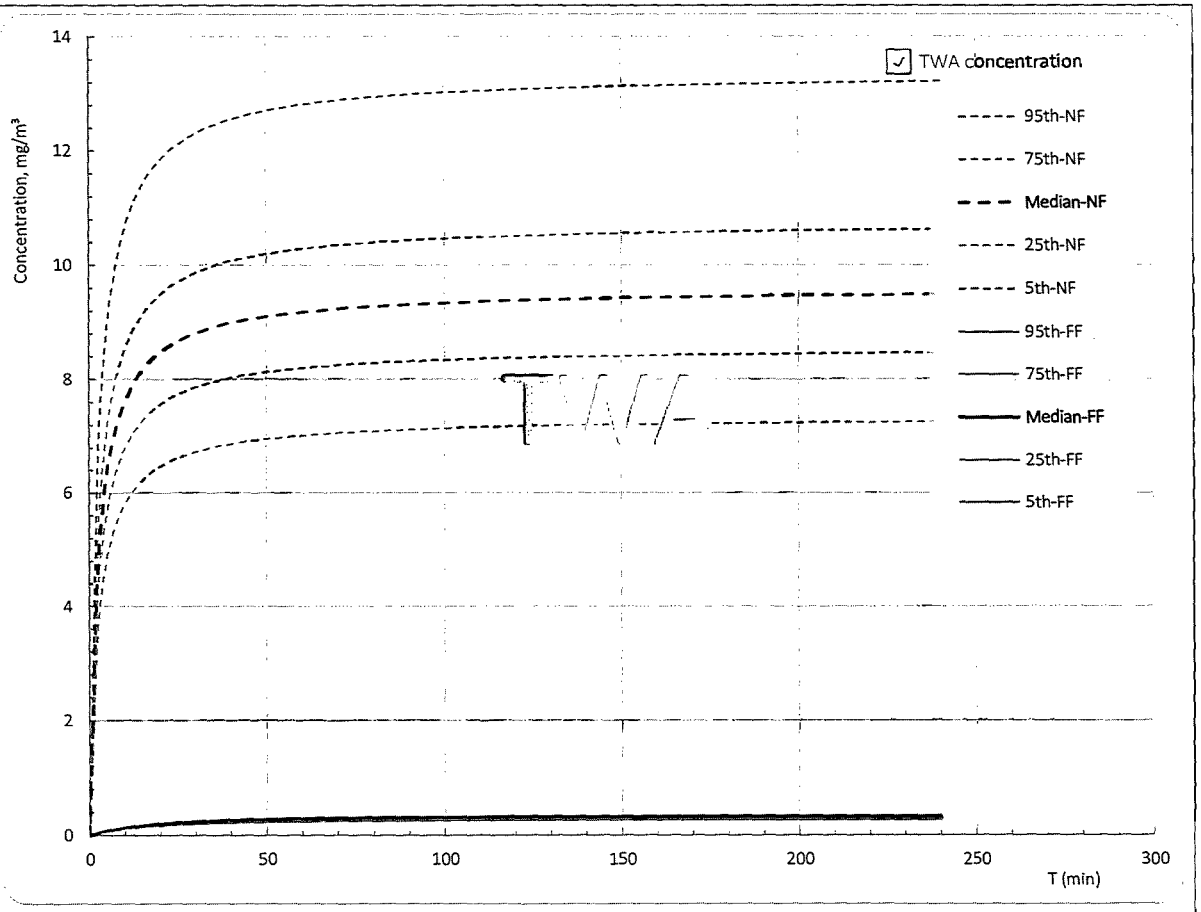
½ Sphere

Radius: 0.76 m

$\beta = \frac{1}{2} \cdot FSA \cdot S$

FSA	3.63 m²
Velocity (S)	3.7 m/min
ß (central value)	6.72 m³/min

4-Near Field Volume (m³)	0.919 m³
5-Room volume (m³)	1720 m³
6-Maximum time for simulation	240 min
7-Time at the end of generation	240 min



Ex. 6,1 MM Book Tom's Example

$$C_{FF}(t) = \frac{G}{Q} + G\left(\frac{\lambda_1 \cdot V_N + \beta}{\beta}\right)\left(\frac{\beta \cdot Q + \lambda_2 \cdot V_N(\beta + Q)}{\beta \cdot Q \cdot V_N(\lambda_1 - \lambda_2)}\right)\exp(\lambda_1 t) - G\left(\frac{\lambda_2 \cdot V_N + \beta}{\beta}\right)\left(\frac{\beta \cdot Q + \lambda_1 \cdot V_N(\beta + Q)}{\beta \cdot Q \cdot V_N(\lambda_1 - \lambda_2)}\right)\exp(\lambda_2 t)$$

See results

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IH Mod 2.0

The Two-Zone Model with a Constant Emission Rate

Model # 8a

Simulation type

Iterations: 200

451 sec. 89 calc./sec

1- Emission rate (mg/min)

G — Normal

Average	Std. Dev.
105	20

2-Ventilation rate (m³/min)

Q — Normal

Average	Std. Dev.
200	4

3-Random Air Velocity (m/min)

S — Normal

Average	Std. Dev.
3.7	0.5

Near field shape

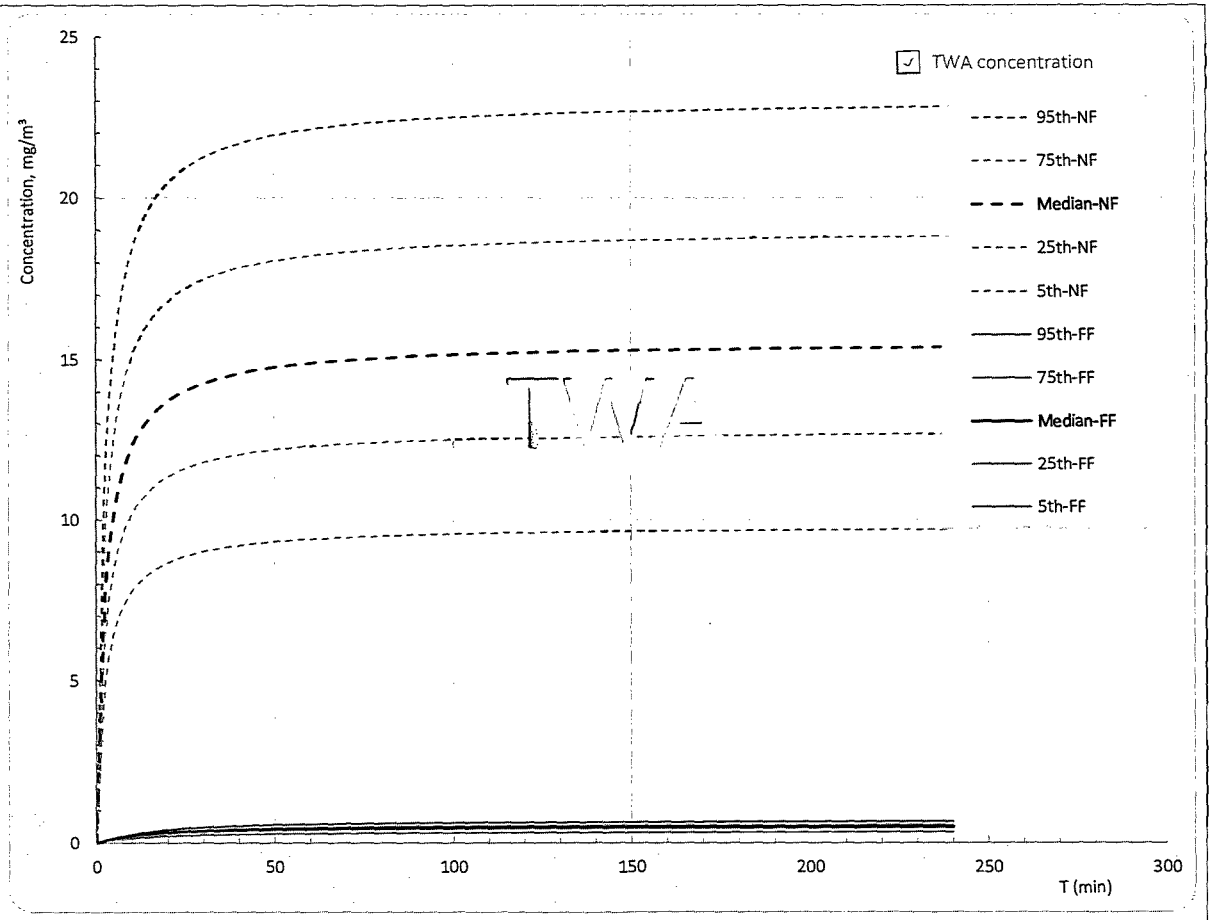
½ Sphere

Radius: 0.76 m

$\beta = \frac{1}{2} \cdot FSA \cdot S$

FSA	3.63 m²
Velocity (S)	3.7 m/min
ß (central value)	6.72 m³/min

4-Near Field Volume (m³)	0.919 m³
5-Room volume (m³)	1720 m³
6-Maximum time for simulation	240 min
7-Time at the end of generation	240 min



$$C_{FF}(t) = \frac{G}{Q} + G\left(\frac{\lambda_1 \cdot V_N + \beta}{\beta}\right)\left(\frac{\beta \cdot Q + \lambda_2 \cdot V_N(\beta + Q)}{\beta \cdot Q \cdot V_N(\lambda_1 - \lambda_2)}\right)\exp(\lambda_1 t) - G\left(\frac{\lambda_2 \cdot V_N + \beta}{\beta}\right)\left(\frac{\beta \cdot Q + \lambda_1 \cdot V_N(\beta + Q)}{\beta \cdot Q \cdot V_N(\lambda_1 - \lambda_2)}\right)\exp(\lambda_2 t)$$

Ex. 6,1 MM Book | Tom's Example

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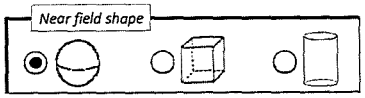
IH Mod 2.0

Two-Zone Model, Constant Emission

Model # 8a Deterministic

		Maximum Value	Value
G	Contaminant mass emission rate	150 mg/min	*105 mg/min*
Q	Room supply/exhaust air rate	200 m³/min	*142 m³/min*
S	Random Air Velocity	5 m/min	*3.55 m/min*

Near field shape



Radius: 0.75 m

½ Sphere

$\beta = \frac{1}{2} \cdot FSA \cdot S$ — *Free Surface area*: 3.53 m² — ß: 6.27 m³/min

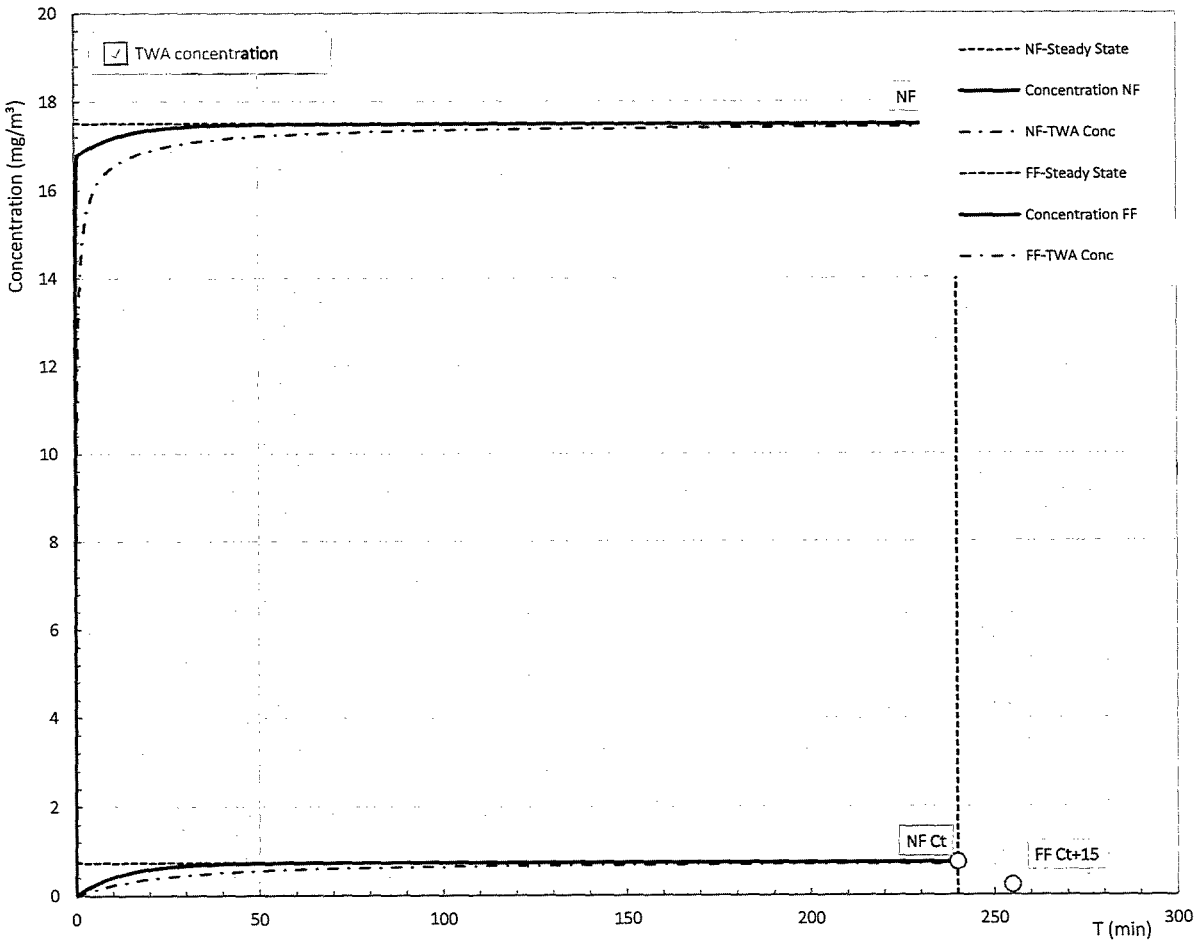
Vr	Room volume	2000 m³ / *1720 m³*
V_{nf}	*Volume Near Field*	0.884 m³
V_{ff}	*Volume Far Field*	1719.116 m³

Maximum time for simulation	240 min	t
Time at the end of generation	240 min	240 min

	Ct	*TWA, Ct to Ct+15*	*Pot. St. State*
Near Field	17.5 mg/m³	17.5 mg/m³	17.5 mg/m³
Far Field	0.739 mg/m³	0.739 mg/m³	0.739 mg/m³

See results

Mass emitted to time t: 25200 mg



$$C_{NF}(t) = \frac{G}{Q} + \frac{G}{\beta} + G\left(\frac{\beta \cdot Q + \lambda_2 \cdot V_{NF}(\beta + Q)}{\beta \cdot Q \cdot V_{NF}(\lambda_1 - \lambda_2)}\right)\exp(\lambda_1 \cdot t) - G\left(\frac{\beta \cdot Q + \lambda_1 \cdot V_{NF}(\beta + Q)}{\beta \cdot Q \cdot V_{NF}(\lambda_1 - \lambda_2)}\right)\exp(\lambda_2 \cdot t)$$

$$C_{FF}(t) = \frac{G}{Q} + G\left(\frac{\lambda_1 \cdot V_N + \beta}{\beta}\right)\left(\frac{\beta \cdot Q + \lambda_2 \cdot V_N(\beta + Q)}{\beta \cdot Q \cdot V_N(\lambda_1 - \lambda_2)}\right)\exp(\lambda_1 t) - G\left(\frac{\lambda_2 \cdot V_N + \beta}{\beta}\right)\left(\frac{\beta \cdot Q + \lambda_1 \cdot V_N(\beta + Q)}{\beta \cdot Q \cdot V_N(\lambda_1 - \lambda_2)}\right)\exp(\lambda_2 t)$$

Version 2.003 : August 2018

This file has been created by Daniel Drolet and Tom Armstrong with review by Michael Jayjc


ck

ART REPORT – Benzene from parts washing – 18-Jun-19

exposures as calculated in LeBlanc 2018

Chemical details

Chemical	benzene
CAS No.	71-43-2

Scenario details

Number of activities	4
Total duration (mins)	13
Nonexposure period (mins)	0

Metadata

ART version	1.5
Creator	herrick@hohp.harvard.edu
Date created	18-Jun-19
Date last edited	18-Jun-19

Details for Activity soak/drip dry

Emission sources:	Near field ✓	Duration (mins):	7
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity spraying

Emission sources:	Near field ✓	Duration (mins):	1
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Surface spraying of liquids
Situation	High application rate (> 3 l/minute)
Spray direction	Only horizontal or downward
Spray technique	Spraying with no or low compressed air use

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity brushing

Emission sources:	Near field ✓	Duration (mins):	1
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Spreading of liquid products
Situation	Spreading of liquids at surfaces or work pieces 0.1 - 0.3 m² / hour

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity air spray/rinse

Emission sources:	Near field ✓	Duration (mins):	4
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with agitated surfaces
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Predicted exposure levels 25C 15 min

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 5.2 mg/m³.

The inter-quartile confidence interval is 2.7 mg/m³ to 10 mg/m³.

Bayesian model results

Data source	Proj. ref.		No. of	No. of	No. of
Cleaning of equipment using immersion techniques			3	3	6
Wiping to clean equipment			3	3	4
		Totals	**6**	**6**	**10**

The predicted 50th percentile long-term exposure is 32 mg/m³.

The inter-quartile confidence interval is 24 mg/m³ to 42 mg/m³.

ART REPORT – Benzene from parts washing – 18-Jun-19

exposures as calculated in LeBlanc 2018

Chemical details

Chemical	benzene
CAS No.	71-43-2

Scenario details

Number of activities	4
Total duration (mins)	60
Nonexposure period (mins)	0

Metadata

ART version	1.5
Creator	herrick@hohp.harvard.edu
Date created	18-Jun-19
Date last edited	18-Jun-19

Details for Activity soak/drip dry

Emission sources:	Near field ✓	Duration (mins):	29
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity spraying

Emission sources:	Near field ✓	Duration (mins):	7
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Surface spraying of liquids
Situation	High application rate (> 3 l/minute)
Spray direction	Only horizontal or downward
Spray technique	Spraying with no or low compressed air use

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity brushing

Emission sources:	Near field ✓	Duration (mins):	7
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Spreading of liquid products
Situation	Spreading of liquids at surfaces or work pieces 0.1 - 0.3 m² / hour

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity air spray/rinse

Emission sources:	Near field ✓	Duration (mins):	17
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with agitated surfaces
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Predicted exposure levels 25C 60 min

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 7.1 mg/m³.

The inter-quartile confidence interval is 3.7 mg/m³ to 14 mg/m³.

Bayesian model results

Data source	Proj. ref.	No. of sites	No. of	No. of
Cleaning of equipment using immersion techniques		3	3	6
Wiping to clean equipment		3	3	4
	Totals	**6**	**6**	**10**

The predicted 50th percentile long-term exposure is 33 mg/m³.

The inter-quartile confidence interval is 25 mg/m³ to 43 mg/m³.

ART REPORT – Benzene from parts washing 2 hours duration 25C – 30-Jul-19

exposures as calculated in LeBlanc 2018

Chemical details

Chemical	benzene
CAS No.	71-43-2

Scenario details

Number of activities	4
Total duration (mins)	120
Nonexposure period (mins)	0

Metadata

ART version	1.5
Creator	herrick@hohp.harvard.edu
Date created	18-Jun-19
Date last edited	30-Jul-19

Details for Activity soak/drip dry

Emission sources:	Near field ✓	Duration (mins):	58
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity spraying

Emission sources:	Near field ✓	Duration (mins):	14
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Surface spraying of liquids
Situation	High application rate (> 3 l/minute)
Spray direction	Only horizontal or downward
Spray technique	Spraying with no or low compressed air use

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity brushing

Emission sources:	Near field ✓	Duration (mins):	14
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Spreading of liquid products
Situation	Spreading of liquids at surfaces or work pieces 0.1 - 0.3 m² / hour

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity air spray/rinse

Emission sources:	Near field ✓	Duration (mins):	34
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with agitated surfaces
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 7.1 mg/m³.

The inter-quartile confidence interval is 3.6 mg/m³ to 14 mg/m³.

Bayesian model results

Data source	Proj. ref.		No. of	No. of	No. of
Cleaning of equipment using immersion techniques			3	3	6
		Totals	**3**	**3**	**6**

The predicted 50th percentile long-term exposure is 24 mg/m³.

The inter-quartile confidence interval is 17 mg/m³ to 33 mg/m³.

Notes/Comments/Justifications

2 hr PW 25C

ART REPORT – Benzene from parts washing 3 hours duration 25C – 30-Jul-19

exposures as calculated in LeBlanc 2018

Chemical details		
Chemical	benzene	
CAS No.	71-43-2	
Scenario details		
Number of activities	4	
Total duration (mins)		180
Nonexposure period (mins)	0	
Metadata		
ART version	1.5	
Creator	herrick@hohp.harvard.edu	
Date created	18-Jun-19	
Date last edited	30-Jul-19	

Details for Activity soak/drip dry

Emission sources:	Near field ✓	Duration (mins):	87
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity spraying

Emission sources:	Near field ✓	Duration (mins):	21
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Surface spraying of liquids
Situation	High application rate (> 3 l/minute)
Spray direction	Only horizontal or downward
Spray technique	Spraying with no or low compressed air use

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m^2

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity brushing

Emission sources:	Near field ✓	Duration (mins):	21
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Spreading of liquid products
Situation	Spreading of liquids at surfaces or work pieces 0.1 - 0.3 m² / hour

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Details for Activity air spray/rinse

Emission sources:	Near field ✓	Duration (mins):	51
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with agitated surfaces
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface 0.3 - 1 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 7.2 mg/m³.

The inter-quartile confidence interval is 3.7 mg/m³ to 14 mg/m³.

Bayesian model results

Data source	Proj. ref.		No. of	No. of	No. of
Cleaning of equipment using immersion techniques			3	3	6
		Totals	**3**	**3**	**6**

The predicted 50th percentile long-term exposure is 24 mg/m³.

The inter-quartile confidence interval is 17 mg/m³ to 33 mg/m³.

Notes/Comments/Justifications

2 hr PW 25C

ART REPORT – fresh MS parts washing – 21-Jun-19

Washing critical transmission parts in 5 gallon bucket of fresh mineral spirits

Chemical details

Chemical	benzene
CAS No.	71-43-2

Scenario details

Number of activities	1
Total duration (mins)	60
Nonexposure period (mins)	0

Metadata

ART version	1.5
Creator	herrick@hohp.harvard.edu
Date created	19-Jun-19
Date last edited	19-Jun-19

Details for Activity washing critical transmission parts 50 ppm MS

Emission sources:	Near field ✓	Duration (mins):	60
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	8.95E-05
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with agitated surfaces
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface > 3 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Predicted exposure levels fresh MS 1 hr 50 ppm

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 5.8 mg/m³.

The inter-quartile confidence interval is 3 mg/m³ to 11 mg/m³.

Bayesian model results

Data source	Proj. ref.		No. of	No. of	No. of
Cleaning of equipment using immersion techniques			3	3	6
		Totals	**3**	**3**	**6**

The predicted 50th percentile long-term exposure is 23 mg/m³.

The inter-quartile confidence interval is 15 mg/m³ to 31 mg/m³.

ART REPORT – fresh MS parts washing – 21-Jun-19

Washing critical transmission parts in 5 gallon bucket of fresh mineral spirits

Chemical details

Chemical	benzene
CAS No.	71-43-2

Scenario details

Number of activities	1
Total duration (mins)	60
Nonexposure period (mins)	0

Metadata

ART version	1.5
Creator	herrick@hohp.harvard.edu
Date created	19-Jun-19
Date last edited	19-Jun-19

Details for Activity washing critical transmission parts 500 ppm MS

Emission sources: Near field ✓ Far field ✓ Duration (mins): 60

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000895
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with agitated surfaces
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface > 3 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Predicted exposure levels 1 hr 500 ppm benz

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 19 mg/m³.

The inter-quartile confidence interval is 9.7 mg/m³ to 37 mg/m³.

Bayesian model results

Data source	Proj. ref.		No. of	No. of	No. of
Cleaning of equipment using immersion techniques			3	3	6
		Totals	**3**	**3**	**6**

The predicted 50th percentile long-term exposure is 31 mg/m³.

The inter-quartile confidence interval is 23 mg/m³ to 42 mg/m³.

ART REPORT – fresh MS parts washing – 19-Jun-19

Washing critical transmission parts in 5 gallon bucket of fresh mineral spirits

Chemical details

Chemical	benzene
CAS No.	71-43-2

Scenario details

Number of activities	1
Total duration (mins)	60
Nonexposure period (mins)	0

Metadata

ART version	1.5
Creator	
Date created	19-Jun-19
Date last edited	01-Jan-01

Details for Activity washing critical transmission parts

Emission sources:	Near field ✓	Duration (mins):	60
	Far field ✓		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.0018
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with agitated surfaces
Situation	Open surface 0.3 - 1 m²

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Far-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.000104
Activity coefficient	1.5

Activity emission potential

Activity class	Activities with relatively undisturbed surfaces (no aerosol formation)
Situation	Open surface > 3 m²

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Segregation	No segregation (0.00 % reduction)

Predicted exposure levels 1 hr fresh MS

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 34 mg/m³.

The inter-quartile confidence interval is 17 mg/m³ to 66 mg/m³.

Bayesian model results

Data source	Proj. ref.		No. of	No. of	No. of
Cleaning of equipment using immersion techniques			3	3	6
		Totals	**3**	**3**	**6**

The predicted 50th percentile long-term exposure is 35 mg/m³.

The inter-quartile confidence interval is 26 mg/m³ to 46 mg/m³.

ART REPORT – spraying CRC – 29-Jul-19

cleaning parts with CRC aerosol 10 ppm bz

Chemical details

Chemical	benzene
CAS No.	71-43-2

Scenario details

Number of activities	1
Total duration (mins)	60
Nonexposure period (mins)	0

Metadata

ART version	1.5
Creator	
Date created	29-Jul-19
Date last edited	01-Jan-01

Details for Activity spraying parts

Emission sources:	Near field ✓	Duration (mins):	60
	Far field		

Near-field exposure

Operational Conditions

Substance emission potential

Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	1.8E-05
Activity coefficient	1

Activity emission potential

Activity class	Surface spraying of liquids
Situation	Low application rate (0.03 – 0.3 l/minute)
Spray direction	Only horizontal or downward
Spray technique	Spraying with no or low compressed air use

Surface contamination

Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes

Dispersion

Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls

Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)

Dispersion

Ventilation rate	Only good natural ventilation

Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 0.59 mg/m³.

The inter-quartile confidence interval is 0.3 mg/m³ to 1.1 mg/m³.

Bayesian model results

Data source	Proj. ref.		No. of	No. of	No. of
Spraying paint with LEV			3	3	6
Spraying paint with LEV			2	5	5
		Totals	**5**	**8**	**11**

The predicted 50th percentile long-term exposure is 47 mg/m³.

The inter-quartile confidence interval is 18 mg/m³ to 77 mg/m³.

ART REPORT – spraying CRC – 29-Jul-19

cleaning parts with CRC aerosol

Chemical details

Chemical	benzene
CAS No.	71-43-2

Scenario details

Number of activities	1
Total duration (mins)	60
Nonexposure period (mins)	0

Metadata

ART version	1.5
Creator	
Date created	29-Jul-19
Date last edited	01-Jan-01

Details for Activity spraying parts

Emission sources:	Near field ✓	Duration (mins):	60
	Far field		

Near-field exposure

Operational Conditions

Substance emission potential	
Substance product type	Liquids
Process temperature	298 K
Vapour pressure	12685 Pa
Liquid mole fraction	0.00018
Activity coefficient	1
Activity emission potential	
Activity class	Surface spraying of liquids
Situation	Low application rate (0.03 – 0.3 l/minute)
Spray direction	Only horizontal or downward
Spray technique	Spraying with no or low compressed air use
Surface contamination	
Process fully enclosed?	No
Effective housekeeping practices in place?	No
General housekeeping practices in place?	Yes
Dispersion	
Work area	Indoors
Room size	Any size workroom

Risk Management Measures

Localised controls	
Primary	No localized controls (0.00 % reduction)
Secondary	No localized controls (0.00 % reduction)
Dispersion	
Ventilation rate	Only good natural ventilation

Predicted exposure levels

ART predicts air concentrations in a worker's personal breathing zone outside of any Respiratory Protection Equipment (RPE). The use of RPE must be considered separately.

Mechanistic model results

The predicted 50th percentile long-term exposure is 5.9 mg/m³.

The inter-quartile confidence interval is 3 mg/m³ to 11 mg/m³.

Bayesian model results

Data source	Proj. ref.		No. of	No. of	No. of
Spraying paint with LEV			3	3	6
Spraying paint with LEV			2	5	5
		Totals	**5**	**8**	**11**

The predicted 50th percentile long-term exposure is 95 mg/m³.

The inter-quartile confidence interval is 72 mg/m³ to 120 mg/m³.